
IN HOC SIGNO VINCES
Berry of Tayfield

SUPPLEMENT

ENCYCLOPAEDIA BRITANNICA

# SUPPLEMENT

TO THE

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# SUPPLEMENT

TO THE

FOURTH, FIFTH, AND SIXTH EDITIONS

OF THE

# ENCYCLOPÆDIA BRITANNICA.

WITH PRELIMINARY DISSERTATIONS

ON THE

HISTORY OF THE SCIENCES.

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**Illustrated by Engravings.**

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VOLUME FIRST.

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# PREFACE.

As the *Encyclopædia Britannica* differed considerably from every work of the kind by which it was preceded, it may be useful, briefly to notice the more important of those works, before giving any account of that Encyclopædia and the improvements it has successively received, or of this *Supplement* to its later editions.

Though the term Encyclopædia is of Grecian origin, the works to which it has been applied belong all to the modern world. Pliny's *Natural History* has been sometimes called the Encyclopædia of the Ancients; and he tells us himself, in his preface, that it embraces all that the Greeks included under that term; but it is only in the compass and variety of its contents that it can be said to resemble the modern Encyclopædias. Its method is that of a work chiefly descriptive; it being no part of the author's plan to examine and classify the objects of inquiry according to their scientific relations; or to point out the place they ought to hold in the Circle of Knowledge. The object which the compilers of the first Encyclopædias proposed to themselves, was, to reduce every thing comprehended within that Circle to a systematic form; and their works accordingly consisted of a series of Systems, intended to exhibit an orderly Digest of all, or of some of the most important branches of Knowledge and Art. Such seems to have been the object of various works, published under the title of Encyclopædias, during the latter half

of the sixteenth, and first half of the seventeenth century; and if we are to look for any earlier exemplars, it must be among the unpublished remains of the Arabian writers of the middle ages. One of the most celebrated of them, Alfarabius, the great ornament of the School of Bagdad in the tenth century, is mentioned as the author of an Encyclopædia, seemingly of this description. The only notice of it that has yet appeared, is that given by Casiri, in his curious and valuable account of the works of the Arabian authors, preserved in manuscript in the library of the Escurial at Madrid. He describes it as a treatise, "ubi Scientiarum Artiumque liberalium Synopsis occurrit, una cum accurata et perspicua earum notitia, definitione, divisione, methodo;" mentioning, at the same time, that it is inscribed with the title of Encyclopædia.[1]

The most noted and valuable of the early Encyclopædias[2] was that of John Henry Alstedius, a Professor of Philosophy and Calvinistic Divinity, first at Herborn in the county of Nassau, afterwards at Weissembourg in Transylvania; and who is said to have been the author of about sixty other works, though he died at the age of fifty, in 1638.[3] His Encyclopædia, by which alone his name is remembered, appeared in 1630, in two large folio volumes. A smaller and less comprehensive work of the same kind, published by him ten years before, served as the groundwork of this more extensive undertaking; in which he professedly aimed at the formation of a complete Encyclopædia.[4] It consists of thirty-five books, of which the first four are introductory; containing an explanation of the nature and requisites of the various studies which form the subjects of the rest. Then follow successively, six books on Philology; ten on speculative, and four on practical Philosophy; three on Theology, Jurisprudence, and Medicine; three on the mechanical Arts; and five on History, Chronology, and Miscellaneous subjects. This work continued to be held in considerable estimation, till the close of that century. Leibnitz mentions it, in the early part of the next,

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1 Casiri, *Bibliotheca Arabico-Hispana Escurialensis,* T. I. p. 189.

2 For a list of them, see the *Bibliotheca Realis Philosophica* of Lipenius, T. I. 436-7.

3 Niceron, *Mémoires des Hommes illustres,* T. XLI. p. 300.

4 His own definition of such a work is as follows:—"Encyclopædia est systema omnium systematum, quibus res, homine dignæ, methodo certâ explicantur." *Encyclop.* T. I. p. 49.

in respectful terms; accompanied, however, with an earnest wish, that some of the learned would either join in remodelling and improving it, or in forming another work of the same kind.[1] His observations show, that he had reflected much on the nature of such an undertaking; and that he considered an Encyclopædia as a species of publication calculated to be eminently useful to mankind.

After what has been said of the early Encyclopædias, it is scarcely necessary to observe, that though the term Encyclopædia is now familiarized to us as the appellative for Dictionaries of Science and general Knowledge, the works to which it was first applied were by no means constructed in the form of Dictionaries. It was long before the idea occurred, that the whole Circle of Knowledge might be comprehended, and discussed, in a work digested in that convenient method; or that any thing could be done towards fulfilling the objects aimed at in these Encyclopædias, if it were adopted. Nearly a century elapsed from the publication of Alstedius's Encyclopædia, before any considerable attempt was made to present the world with an Encyclopedical Dictionary.

Dictionaries of technical terms, and Dictionaries explaining the rudiments of particular sciences, had been long in use throughout Europe; but the first work of the kind professing to embrace a detailed view of the whole body of the Sciences and Arts was the *Lexicon Technicum* of Dr Harris. This work was published at London in 1710,[2] and is generally regarded as the first great advance to the form and objects of the more modern Encyclopædias. But, though professing to be "an Universal Dictionary of the Arts and Sciences, explaining not only the terms of art, but the arts themselves," its explanations were mostly confined to the mathematical and physical sciences; with respect to which, it has always been allowed, that it was fully on a level with the knowledge of that age.

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[1] "Operæ pretium esset, *Encyclopædiam* Alstedii perfici et emendari. Defuit viro optimo non labor, non judicium, sed materia, sed nostri temporis felicitas."—"Itaque vellem ut aliquot Eruditorum et bene animatorum studio componeretur *opus Encyclopædiæ*, qualem olim tentavit Alstedius; sed quæ nunc tota refundenda est, ob innumera maximi momenti, quæ ab eo tempore accessere." Leibnitii *Opera*, T. V. p. 183—405.

[2] The first of the two folio volumes of which it consists, was published in 1706. Before 1741, when a Supplement to it was published, it had passed through five editions.

In 1728, the *Cyclopædia* of Mr Chambers was given to the Public; and its appearance constitutes an era in the history of Encyclopedias; as exemplifying the first attempt that had yet been made at once to arrange Knowledge by the Alphabet, and to exhibit a view of its relations and dependencies. Mr Chambers sets out with stating, that his predecessors did not seem to have been aware, that "a Dictionary is, in some measure, capable of the advantages of a continued discourse;" and therefore, he adds, "we see nothing like a whole in what they have done." In order to remedy this defect, and to unite the objects of an Encyclopædia with those of a Dictionary, he proposed to "consider the several matters, not only in themselves, but relatively, or as they respect each other; both to treat them as so many wholes, and as so many parts of some greater whole." But he still followed the method of splitting the Sciences into parts, corresponding to the terms and topics in each which required elucidation; so that it was not by connected views of these great branches of knowledge, introduced under their general denominations, that he proposed to exhibit those "wholes" by which he was desirous that his Dictionary should be distinguished. He endeavoured to accomplish this, by references from the more general to the less general heads of science, and from these again to the former; conformably to an elaborate Scheme of the divisions and subdivisions of Knowledge prefixed to the work. That something was done, by this plan, to point out the links among connected subjects, disjoined by the Alphabet, and to make its fortuitous distributions subservient to continued inquiry, cannot be questioned; but the inconveniences and defects occasioned by the dismemberment of the Sciences, could not possibly be remedied by any chain of references however complete. The Sciences can only be studied with effect, by being viewed in their appropriate state of unity and coherency; and the term Encyclopædia cannot be applied, with propriety, to any work in which that method of considering them is not observed. Useful purposes may no doubt be served, by explaining the elements of a Science, in the order of the Alphabet; but it seems abundantly clear, that a work intended to include and to delineate the whole Circle of Knowledge, must fall greatly short of its professed object, if it fails to embody the truths of Science in a systematic form. In some other respects, Mr

Chambers's notions of what was required by the nature of his undertaking were confined and arbitrary; as in thinking, that an Encyclopædia should only contain the conclusions, without any of the demonstrations of mathematical, or experimental details of physical science. But, with all its defects, whether of plan or execution, his work must be considered as the production of a mind of no ordinary reach and vigour; as well as one of the greatest and most useful literary undertakings ever accomplished by a single hand. How much has it not done through its numerous editions,[1] and the other works of the same kind to which it gave rise, to stimulate the curiosity, to enlarge the inquiries, and to diversify the knowledge of the mass of mankind!

The popularity of the *Cyclopædia* remained undisturbed by any rival work, for a considerable period; but the success with which it was frequently republished, and the progress of knowledge in some departments in treating of which it was from the first defective, by holding out a prospect of encouragement to newer undertakings, led at length to a series of Universal Dictionaries, modelled upon its plan. The title which Mr Chambers chose, in preference to the more classical one of Encyclopædia, was however laid aside; nor was the latter assumed, in any British work of this class, till the appearance of the *Encyclopædia Britannica.*

The first of the works alluded to, was Barrow's *New and Universal Dictionary of Arts and Sciences*, consisting of a folio volume, published in 1751; to which a supplemental volume was added in 1754. Its only claims to public notice were founded upon an enlarged number of articles on mathematical subjects, on the mechanical arts, and on naval affairs; to make room for which, church history and the scholastic parts of Chambers's work were excluded. A garbled translation of D'Alembert's preliminary *Discourse* to the French *Encyclopédie*, was prefixed, in two portions, to these two volumes, without the slightest acknowledgement or notice of the original.

This was followed in 1754, by a *New and Complete Dictionary of Arts and*

[1] The *Cyclopedia* consisted of two folio volumes, of which there were *five* editions published in the short period of eighteen years. A Supplement, also consisting of two folio volumes, chiefly compiled by Dr Hill, was published in 1754.

*Sciences*, comprised in four large octavo volumes; commonly, from the name of the publisher, referred to under the title of *Owen's Dictionary.* The title page bears, that it was written "by a Society of Gentlemen." It is distinguished by the general brevity of its articles; a quality, which enabled its Compilers to widen its range in the departments of geography, commerce, and natural history. Prefixed to it, there is a new Scheme of the divisions of Human Knowledge, intended to serve as the basis of its articles and references; and which is announced, as "more simple and natural, and likewise fuller and better distributed," than that either of Chambers or of D'Alembert; but which may be fairly characterized as an exceedingly confused and illogical performance, and as exemplifying an extremely arbitrary use of philosophical terms.

In 1766, was published, in three folio volumes, *The Complete Dictionary of Arts and Sciences;* a work compiled under the joint direction of the Reverend Henry Croker, Dr Thomas Williams, and Mr Samuel Clark; the theological, philosophical, and critical branches being supplied, or edited, by the first; those of anatomy, medicine, and chemistry, by the second; and the mathematical by the last. The division of labour among these different hands, does not appear to have contributed much to the excellence of their respective departments; for the character of the whole, with a few exceptions, is that of mere compilation. In point of structure, this work has still less claim to praise; for its authors either did not perceive, or disregarded the use of that Encyclopedical chain of references, by which Chambers and some of his successors, have endeavoured to remedy the defects arising from the division of subjects naturally connected, under a multiplicity of separate heads. A part of D'Alembert's *Discourse* was here also appropriated as an Introduction, without any notice of the quarter from whence it was derived.

Besides these works, all of them founded in the main, upon the plan of Chambers, there appeared before any of them, an Encyclopedical work, of a somewhat different title as well as structure; namely, *An Universal History of Arts and Sciences, or a comprehensive illustration of all Sciences and of all Arts*, by Dr De Coetlogon; a native of France, naturalized in England. This work, which appears to have early sunk into obscurity, was published in 1745, in two folio volumes. Though its title affords no indication that it was

compiled in the form of a Dictionary, its subjects are, nevertheless, treated in alphabetical order; and each Science and Art is discussed in a general treatise;—a part of its plan, which probably suggested a distinguishing feature, to be afterwards mentioned, in that of the *Encyclopædia Britannica.*

On the Continent, as well as in England, the *Cyclopædia* of Chambers gave a new impulse to the desire for such publications. Before the middle of the century, it had been translated into the Italian language; and had, in France, become the foundation of the *Encyclopédie*,—the most extensive and celebrated undertaking of the kind, that had yet appeared in the world. This great work, originally intended to consist of ten, was ultimately enlarged to seventeen folio volumes; of which the first was published in 1751, the last in 1765.[1] It is well known to those who are conversant with its history, that it was founded upon a French translation of Chambers's *Cyclopædia*, at first designed for separate publication. This translation was undertaken in 1743, and completed in 1745, by an Englishman of the name of Mills, assisted by a native of Dantzic, named Sellius.[2] Soon after, a plan was formed for publishing an Encyclopædia, upon a more extensive scale than that of Chambers; and the manuscript translation of his work was put into the hands of its intended Conductors, as the ground-work of the undertaking. It is not, perhaps, so generally known, that the Abbe de Gua was the author of this design; and that it was only in consequence of a dispute between him and the Booksellers concerned, that the execution of it was committed to D'Alembert and Diderot.[3] While both these authors concur in bestowing the highest encomiums upon the Encyclopedical method which Chambers exemplified in his Dictionary, they represent his execution as that of a servile compiler and copyist, particularly from French writers; observing, that the project of publishing the translation of his work was abandoned, because it was discovered, that the public would thereby get little,

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[1] Besides seventeen volumes of Text, it has eleven of Plates and Descriptions; of which the first was published in 1762, the last in 1772.

[2] *Mémoire* pour P. J. F. Luneau De Boisjermain, *Souscripteur de l'Encyclopédie*, p. 2. 4to. Paris, 1771.

[3] *Nouv. Mem. de l'Académie Royale des Sciences de Berlin,* pour l'an. 1770, p. 52.—*Biographie Universelle*, Tom. XVIII. Art. Gua De Malves.

of which they were not already possessed in another form. They at the same time acknowledge, that without the aids derived from the manuscript translation, which was distributed in parts among their Colleagues, it would have been extremely difficult, if not impossible, to procure the co-operation necessary to the composition of the *Encyclopédie*. "Il n'y a presqu'aucun de nos Collegues," says Diderot, "qu'on eût déterminé à travailler, si on lui eût proposé de composer à neuf toute sa partie; tous auroient été effrayés, et *l'Encyclopédie* ne se feroit point faite."[1]

The plan of the work was confessedly modelled upon that of Chambers, which its Editors represent as having obtained the suffrages of the learned throughout Europe; but which unquestionably leaves vacuities under many heads of Science, but ill supplied by a system of references. Seeking no distinction, therefore, from novelty of plan, they rested its claims to public favour, upon the great extension of all its departments; upon the various attainments and the literary eminence of its Contributors; and, above all, on the philosophical spirit which animated their labours.[2] It would be altogether foreign to the purpose of these notices, to enter into any details concerning the literary history of this celebrated work, or the irreligious and revolutionary designs with which its Conductors have been charged. In respect to its completeness as a repertory of knowledge, it may be observed, that the popular departments of biography and history are excluded from its plan; and, with regard to its literary merits, that though it unquestionably contains articles of great excellence, in many of its departments, there is yet everywhere a large alloy of useless matter, dressed out in a vague, diffuse, and declamatory style.[3] As ex-

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[1] *Encyclopédie*, Art. Encyclopédie, Tom. V. p. 645.

[2] ——— "C'est principalement par l'esprit philosophique que nous tacherons de distinguer ce Dictionnaire." D'Alembert, *Preface du troisième volume de l'Encyclopédie.*

[3] The severest censure ever pronounced in regard to its general merits and consistency as a Digest of Knowledge, is that contained in the following singular passage from the pen of Diderot, its principal Editor:—"Ici nous sommes boursouflés et d'un volume exorbitant; là maigres, petits, mesquins, secs et décharnés. Dans un endroit, nous ressemblons à des squeletes; dans un autre, nous avons un air hydropique; nous sommes alternativement nains et géants, colosses et pigmées; droits, bien faits et proportionnés; bossus, boiteux et contrefaits. Ajoûtez à toutes ces bisarreries celle d'un discours tantôt abstrait, obscur on recherché, plus souvent négligé, trainant et lâche; et vous comparerez l'ouvrage entier au monstre de l'art poetique, ou même à quelque chose de plus hideux." *Encyclopédie*, Art. Encyclopédie. T. V. p. 641.

emplifying the first attempt that had yet been made, in any age or country, to combine the talents of a number of literary and scientific men, some of them occupying the highest stations in the Republic of Letters, in the composition of a Digest of Human Knowledge, upon a scale commensurate to the magnitude and importance of the object, this Encyclopædia must always, however, be viewed as fixing a remarkable era in the history of that important class of publications.

One proof of its influence in recommending such undertakings as worthy the co-operation of the highest class of literary men, may, perhaps, be found, in Dr Goldsmith's project for publishing "An Universal Dictionary of Arts and Sciences," with the promised assistance of many of the most distinguished writers of that day.[1] This plan was unfortunately frustrated by his untimely death; and it is matter of regret, that his *Prospectus*, described by his biographer as "giving a luminous view of his design," was not permitted to reach the Public.

A few years after the conclusion of the French *Encyclopédie*, the *Encyclopædia Britannica* began to be published. The first edition, consisting of only three quarto volumes, was completed at Edinburgh, in the year 1771. Compared with other works of the same kind, previously published in England, it had no superiority in point of execution; but it was certainly distinguished by a far happier and more philosophical plan. Instead of attempting to communicate a knowledge of the several Sciences by a number of separate articles, corresponding to the technical terms and heads of inquiry respectively belonging to them, its Compilers proceeded upon the assumption, that as the Sciences consist of connected serieses of principles and conclusions, it was necessary to treat them compendiously in the form of systems, under their general denominations; the technical terms, and subordinate heads, being also explained, when something more than a reference to the proper part of each system was required, in the order of the alphabet. This plan was illustrated upon a wider scale, and with more maturity of method, in the subsequent editions; and, though not always followed out with perfect order

[1] —— "He had engaged all his literary friends, and the members of *The Club*, to contribute Articles, each on the subject in which he excelled; so that it could not but have contained a great assemblage of excellent disquisitions.' *Life* (p. 112), prefixed to the first volume of his *Works*.

and consistency, yet to an extent, exemplifying a great and beneficial improvement, in the arrangement of Encyclopedical Dictionaries. All the more important objects of an Encyclopædia, were thus made attainable, in a work constructed in the form of a Dictionary;—a form freed from the inconveniences which must ever attend the methods pursued in the first Encyclopædias, by the number of its heads of explanation and reference; and which admits of an easy incorporation of any variety of details that may appear conducive to the diffusion of knowledge.

The Editor of the first edition of this Encyclopædia, of which he was also the principal compiler, was Mr William Smellie; by profession a Printer, and then well known as a man of considerable ability and attainments. It has been said, "that the plan of the work was devised by him;"[1] and he was more likely, certainly, to have suggested it, than any other person known to have been connected with the undertaking. The plan, however, was not altogether so original as it was represented. It had been partially exemplified, as has been already hinted, many years before, by Dr De Coetlogon, in his *Universal History of Arts and Sciences*. "I have divided Philosophy," says this author, in delineating the plan of his work, "into Ethics, Logic, and Metaphysics, treating each branch under its proper head; subdividing the fourth, Physics, into several others; each making a whole treatise by itself." In this method, we have the basis of the plan in question; and it seems highly probable, that the primary idea of it was derived from this unnoticed quarter.

In the second edition, published between 1778 and 1783, the work was extended to ten volumes; and it was farther distinguished by the addition of two departments, not hitherto embraced by any similar publication—Biography and History. In the French *Encyclopédie*, though there were occasional notices of remarkable persons in the articles on the history of philosophy and science, there was no series of separate lives; and no place whatever was assigned to civil history. The Supplement to that work professed to include history in its plan;[2] but its his-

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[1] Kerr's *Memoirs of William Smellie*, Vol. I. p. 361.

[2] The Supplement to the *Encyclopédie* was published in 1776–7, in four volumes folio, exclusive of a volume of Plates and Descriptions. This Supplement was followed, in 1780, by an Index to the whole, in two folio volumes.

torical details were introduced, for the most part, under the names of kings and rulers; and thus presented no connected views of the history of states. The introduction of history, in any form, in such a work, is censured by M. De La Harpe as a great impropriety. "L'histoire n'est point," says he, "une acquisition de l'esprit; ce n'est pas dans une Encyclopédie qu'on doit la chercher."[1] The reason here assigned for the exclusion of history is altogether arbitrary; and would exclude equally many other details to which M. De La Harpe makes no objection. It derives no countenance either from the practice of the first Encyclopedists, or from the opinions of the most enlightened of those who have adverted to their labours; for the Encyclopædia of Alstedius contains a general view of the history of the world; and Leibnitz, in pointing out the defects of his work, mentions the historical department as requiring great enlargements.[2] M. De La Harpe ought, besides, to have recollected, that the basis of the modern Encyclopædia is that of an Universal Dictionary; requiring the incorporation of every branch of knowledge that the wishes of the Public may point out as necessary to its completeness. There can be no doubt, that the success of the *Encyclopædia Britannica* was materially promoted, by the extension of its plan to the departments in question; and that any work of the kind, which should now exclude them, would greatly circumscribe the sphere of its usefulness.[3]

As the plan of this Encyclopædia was completed, in its general outline at least, in the second edition of the work, a few observations will suffice to indicate its subsequent improvements.

Till the appearance of the third edition, its method, and the comprehensiveness of its plan, had constituted its chief recommendations; but, in this edition, which was completed in eighteen volumes in 1797, it rose, in several of its departments,

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[1] *Cours de Littérature*, Tom. XV. p. 74.

[2] Leibnitii *Opera*, T. V. p. 184.

[3] We are told by his biographer, that Mr Smellie "refused to take a share of the work, and to superintend the construction of the second edition, because the other persons concerned, it has been said, on the suggestion of a distinguished nobleman, insisted upon the introduction of a system of general biography." Kerr's *Memoirs of William Smellie*, Vol. I. p. 363. The present Editor has been informed that the Duke of Buccleuch was the nobleman here alluded to.

greatly above its former level ; and in that of Physical Science in particular, it acquired, through the valuable assistance of Professor Robison, a high degree of scientific eminence. His accession did not, however, take place till the work was advanced to the thirteenth volume ; a little before which period, it had been committed, owing to the death of the Editor, Mr Colin Macfarquhar, [1] to the direction of the Reverend Dr Gleig. In a Supplement of two volumes, also executed under his direction, Professor Robison completed that series of articles, which he had commenced in the principal work ; the whole, to use the words of a very competent judge, "exhibiting a more complete view of the modern improvements of Physical Science, than had ever before been in the possession of the British Public." [2]

The division of the editorial labour between two successive Editors, though both were well qualified for the task, was a circumstance very unfavourable to unity and consistency of design and execution. In the fourth edition, which was completed in twenty volumes, in 1810, under the undivided and able superintendence of Dr James Millar, the work assumed a form more consistent with the principles of its plan than it had yet done in any preceding edition ; and it was enriched with a number of new articles in various departments of Science and Learning ; among which, those of Professor Wallace in the department of pure mathematics hold a distinguished place. This edition would have been rendered still more valuable, had its Editor been at liberty to avail himself fully of Professor Robison's articles in the supplemental volumes to the third ; but this was prevented, by a temporary separation of the right of property in these volumes, from that in the principal work.

Another impression having been called for, almost immediately after the fourth was finished, the fifth edition was, in consequence, issued without any material change. The sixth, lately completed, has the advantage of references to many of the articles contained in the present work ; which stands in the same relation to the three last editions of the *Encyclopædia Britannica*.

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[1] Mr Macfarquhar was a Printer, and one of the original proprietors of the work. Dr Gleig, who knew him well, speaks of him, in the *Preface* to the third edition, as being "eminently qualified for superintending the publication of an Encyclopædia." The second edition, it is believed, was chiefly conducted by him.

[2] See Dr Young's Article on Professor Robison, in this Work.

While the fifth edition was in progress, the work fortunately became the property of its present owners. The formation of an Encyclopædia suitable in all respects to the knowledge, taste, and attainments of the age, and therefore to be composed by men of known acquirements in the various branches of Science and Literature, had been long meditated by Mr Constable; and it was in this spirit that, after becoming the principal proprietor of the *Encyclopædia Britannica*, he conceived the design of a *Supplement*, of such extent as to afford scope for large additions and improvements; and of such a complexion, as should recommend it to the general attention and assistance of the Literary world. This latter object was happily aided by the co-operation of two illustrious Philosophers; who, duly appretiating the utility of the undertaking, and the liberal and enlightened spirit of literary enterprise in which it was conceived, agreed to contribute jointly an Historical Account of the progress of the Sciences, calculated both to supply a desideratum in our domestic literature, and to form a fit Introduction for such a work.

The task of superintending this *Supplement* having been committed to the present Editor, it became necessary for him, to subject the extensive publication to which it was to be appended, with the contents of which he had previously but little acquaintance, to an accurate examination throughout. He is happy to acknowledge, that he was materially assisted in this laborious survey by an eminent friend, whose profound knowledge in the mathematical and physical sciences rendered his observations of the greatest value; and whose contributions, in these departments of the present work, display the same originality, ingenuity, vigour of thinking, and extent of information by which his name is so much distinguished in the annals of Science.

A difficult and embarrassing task remained to be performed, after the labour of this survey was surmounted. The omissions with which the fourth edition of the *Encyclopædia* was originally chargeable, presented a long list of particulars and topics that might be made the subjects of articles and treatises; the subsequent progress of discovery, of inquiry, and of events, furnished another; and it was necessary to make a selection from the whole;—determining, at the same time, in what cases subjects already treated were to be considered anew, and the proper form of the additions, in those cases where the defects were such as might be supplied in that way. In making these selections and adjustments, there were vari-

ous circumstances requiring throughout a simultaneous attention. Besides always keeping in view the limits assigned to the work, it was necessary to attend to the comparative strength or weakness of the *Encyclopædia* in the several departments of knowledge which it embraces; to the comparative importance, novelty, and interest of the various topics presenting themselves for discussion; and to the modes of thinking, the prevailing subjects of speculation and inquiry, and the spirit of the times. There may be room enough to question the judgment and intelligence with which all this has been done; but the Editor hopes it will, at any rate, be allowed, that he has committed no great mistake, with respect to the nature of the duties and considerations by which it was proper for him to be guided in the adjustment of his plan; and he can only say, that he has used his best endeavours to regulate the work in compliance with what they seemed to him to require and prescribe. He will have occasion again to recur to them, in the following Outline of its contents; and he has the satisfaction of thinking, that even this Outline, but much more the examination of the work itself, will show, that it possesses claims to Public attention which cannot be impaired by any defects connected with his own responsibility. It will appear, that it has been composed by a numerous body of learned and ingenious men; most of them well known to the world; many of them ranking among the most illustrious ornaments of the Science and Literature of the present age. It will further appear, that it has been executed in a way calculated to render it extensively useful, independently of its connection with the work to which it is appended;—in a word, that it contains great and important additions to the stock of knowledge, in almost every department of Science and Learning.

In presenting an Outline of the contents of the work, it is not intended either to enumerate every article particularly worthy of notice, or to state fully the objects of those actually mentioned. Neither is it intended to mention the names of all its Contributors. All that is intended is, to give the reader a general view of the subjects and information which it embraces; and this the Editor shall attempt in a methodical form, but without aiming at an exact classification of all the subjects that may be noticed. In the Table at the end of the last volume, there will be found a complete enumeration, in alphabetical order, of Articles and Treatises; and in that annexed to this Pre-

face, a full list of their Authors; arranged in the alphabetical order of the Signatures by which their respective contributions are distinguished.

The Articles belonging to the SCIENCES AND ARTS obviously claim the first place, as well as the fullest description, in this Outline. In noticing them, the Editor shall first advert to those which range under the Mathematical and Physical Sciences; next, to those on the Arts and Manufactures dependent on, or connected with these Sciences; and lastly, to those relating to the Philosophy of the Mind, and Political Philosophy.

As the *Encyclopædia* is more complete in the department of *Pure Mathematics* than in many other branches of knowledge, it would have been improper, though much was still found wanting, to assign any considerable portion of the present work to that department. Room has, however, been made for several Mathematical articles.

Arithmetic forms the subject of an article of considerable extent; containing, not a mere statement of rules, but a philosophical exposition of the principles of numerical processes, and of the steps by which mankind advance in the acquisition of the art of computation. This article was written by Professor Leslie; to whose assistance, in a preparatory stage of the work, the Editor has already had occasion to allude; and to whom the present department is farther indebted for the articles Angle, and Trisection of an Angle. The doctrine of Equations, already partly discussed in the Encyclopædia, under Algebra, is here reconsidered in a distinct article; containing a view of the present state of knowledge upon the subject, and some new solutions of problems hitherto attended with difficulty; particularly in that part of it which relates to Gauss's theory of Binomial Equations. This important article was contributed by Mr Ivory. Under the term Differential Calculus, Sir Edward Ffrench Bromhead has given a systematic view of the subject in its latest form. Under the term Fluents, or Integrals, the fluents of such expressions as are the most likely to occur in the solution of physical problems, are arranged in the form of a Table, by Dr Thomas Young; to whose profound and accurate knowledge, rare erudition, and other various attainments, this work is largely indebted in almost every department which it embraces.

In connection with these algebraical articles, the treatise on Annuities and Assurances on Lives, by Mr Joshua Milne, may be mentioned; in which, however, its experienced author, by a useful division of his subject, has addressed himself as well to those who have not, as to those who have, an acquaintance with Algebra.

The articles in *Natural Philosophy* are numerous and various; extending through every head of that great division of Physical Science.

To the head of Mechanics, may be referred the valuable article Bridge, by Dr Young, and that on Weights and Measures by the same author; both containing the substance of all the more recent discussions in regard to the principles involved in their respective subjects. The article Pendulum, written by M. Biot, belongs also to this head. Besides explaining the laws of the motion of this instrument, it describes, at considerable length, the principal purposes to which it has of late been applied in the physical sciences.

Capillary Attraction, and the Cohesion of Fluids, subjects shortly explained in the general treatise under the head of Hydrodynamics, in the Encyclopædia, have been resumed in this work, for the purpose of fuller discussion, and the statement of some later views and experiments. The article on the first of these subjects was contributed by Mr Ivory; that on the other by Dr Young; who has also, in an article on Hydraulics, written as a supplement to the general treatise just mentioned, explained the later attempts to improve the theory of this branch of science. The articles on Breakwaters, and on Docks, may be mentioned as contributions to the division of Natural Philosophy now in view; because relating to works whose construction depends on hydrostatic and hydraulic principles. The first is particularly valuable, as containing an accurate account of the two greatest works of the kind in existence—the one at Cherbourg, the other in Plymouth Sound; the latter, now nearly completed, constituting one of the many durable monuments of the great professional genius and resources of the late eminent Engineer, Mr Rennie. For this article, and many others, the Editor is indebted to the distinguished assistance of Mr Barrow; who has enriched the work with much valuable and various information, that could not have been obtained in so satisfactory a form, if at all, from any other quarter.

The extensive branch of Pneumatics has been elucidated in a number of articles, containing many new facts and views; most of them contributed by Professor Leslie. Under the article Acoustics he has examined the later experiments and opinions as to the theory of Sound. Though the Encyclopædia contains an account of the invention and construction of Balloons, it was judged proper to resume the consideration of these machines, in order to afford an opportunity of tracing the progress of discovery with greater precision, and of explaining the calculation of their ascent and stability. This has been done in the article Aeronautics, where, also, the more remarkable of the later aërial voyages are described. With a view, in like manner, more fully to explain the successive steps which led to the discovery of atmospheric pressure, and to state and examine the various formulas that have been proposed for determining heights by the Barometer, there have been given two articles on that instrument, and its uses in measuring elevations. The connected subjects of Climate, Cold, Dew, and Meteorology, rank under Pneumatics, in so far as they can be considered as belonging to Natural Philosophy; but the phenomena to which they relate depend upon principles which place them, partly, within the province of Chemistry. In the very valuable series of articles here given upon these subjects, the author has accordingly drawn his reasonings and illustrations from either department. The last of them contains a copious explanation, of the theory and applications, of all the different instruments capable of being employed in Meteorological Observations; a portion of it calculated to be eminently useful to those engaged in such observations, or in directing the proper preparations for making them. Besides the above articles by Professor Leslie, there are some others, by different writers, on subjects connected with the present head. Such are the articles on Blowing Machines; on the application of the Steam-Engine to the propulsion of Vessels; and on the new Steam-Engine proposed by Mr Perkins.

Of the numerous discoveries made during the present century relative to the theory of Colours, and the Double Refraction and Polarisation of Light, an account will be found, in two articles on those interesting branches of Optics, by Dr Young and M. Arago. There is also an instructive article, written by Professor Leslie, containing an historical review of those optical controversies and discoveries which, after the long intermission consequent on the death of Newton, terminated in the construction of the Achromatic Telescope.

Astronomy forms the subject of one of the most extensive treatises in the *Encyclopædia*, and nothing has been added, in the present work, upon the descriptive and more popular parts of the science; but its higher branches have received some important illustrations. Under the head of Physical Astronomy, there is a general view, by the late Professor Playfair, of the laws which regulate the celestial motions, as discovered by Newton and the philosophers who have succeeded him. Under Attraction, Mr Ivory has given, in a series of distinct propositions, a complete theory, as remarkable for its simplicity and elegance as for its depth, of all that has been discovered relating to the attractions of Elliptical Spheroids. The subject of the Tides, though ably discussed in the *Encyclopædia*, has been resumed, with great advantage to science, in an article by Dr Young; who has here extended the theory, to the effects of hydraulic resistances of various kinds, which had not been computed by any preceding inquirer.

Electricity and Galvanism also form copious articles in the *Encyclopædia*; but it was necessary to give a more correct and determinate view of the theoretical parts of both subjects, than is contained in these articles; and also to add such additional facts as have been brought to light by subsequent experiments. This has been done in two supplemental articles, written by M. Biot; of whom it is but justice to mention the alacrity with which his assistance has been given to a work, where his contributions could not appear in the language in which they were written, and to aid which, he could have no other motive but a love for science, and a desire to improve the means of diffusing it in every country of the world.

In passing from the great division of Natural Philosophy, to the other branches of Physical Science, the Editor may state generally, that in these also, the work contains much new and valuable information, contributed by some of their most distinguished cultivators.

With respect to *Chemistry*, it has the advantage of an instructive historical account of that important science, deduced from the early ages to the close of the last century. This forms one of those Discourses on the History of the Sciences, with which several volumes of the work are prefaced; and it is the only one of the series that has been completed. It was written by Mr Brande, who also contributed a systematic view of the present state of the science; rendered necessary by the

great extension and improvement of Chemical knowledge, since the period when the corresponding article in the *Encyclopædia* was compiled. Farther, in conformity with the plan of that work, two subordinate heads of the science, requiring a fuller explanation than they could conveniently receive in the general treatise, are here discussed in separate articles. The first relates to the great doctrine of definite proportions in chemical combinations, which is explained under the head of Atomic Theory; the other, to the analysis of chemical substances and compounds, for the purpose of discovering their constituent principles, which is treated under Decomposition, Chemical. For these elaborate articles, and several others of great practical utility, in the department of the Chemical Arts and Manufactures, the work is indebted to Dr Thomas Thomson.

Every branch of *Natural History* has received contributions in the present work. Under Mineralogy, there is a systematic view of that branch, founded upon an arrangement derived from the external characters of minerals, lately instituted by Professor Mohs of Freiberg; an arrangement which receives additional credit from its adoption by the distinguished Mineralogist by whom it is here illustrated—Professor Jameson. Besides Mineralogy, properly so called, this article includes a brief summary of Geology; one of the most interesting topics of geological inquiry, that which relates to Organic Remains, being, however, reserved for a separate article; also written by Professor Jameson.

Botany is treated in a very instructive article by Sir James Edward Smith; in which, referring to the *Encyclopædia* for the details of systematic arrangement, he takes a general view of the progress of the science; of the different modes in which it has been cultivated; of the philosophy of its methods; and of the comparative advantages of the artificial and natural systems of Classification. The study of Plants is farther elucidated, in two articles upon their structure and functions; both of them written by Mr Ellis, and possessed of every recommendation that a thorough knowledge of the subject and luminous arrangement can impart. These articles are given under the heads of Anatomy, Vegetable, and Vegetable Physiology.

As the Zoological department of the *Encyclopædia* is founded chiefly upon the Linnæan classification of the animal kingdom, it was intended, both to add the recent discoveries, and to introduce an arrangement more agreeable to the

views of later Naturalists; but, owing to the illness of Dr Leach, by whom the earlier parts of the plan were executed, it has not been completed in all its extent. Some of the later heads, undertaken by him, have been treated by the Reverend Dr Fleming; and, besides the systematic articles, a few of a more popular kind have been contributed by Dr Roget.

That great branch of descriptive science, which, under the name of Physical Geography, draws its materials from all the various divisions of Natural History, in order to present a systematic view of the globe, its productions and inhabitants, is here treated, in a compendious form, by Mr Maclaren; to whom the work is indebted for some very valuable contributions in the department of Statistics.

*Medicine*, and the sciences subservient to that study, have been duly attended to in the formation of the work. Under Anatomy, there is a new outline of the subject, written by the late Dr Gordon. Physiology is fully treated in the *Encyclopædia*, in as far as concerns the principal facts relative to the functions of animal life; but there seemed to be wanting a comprehensive view of the general laws to which they are reducible; a defect which has been ably supplied, in this work, by Dr Roget. The progress made of late years in the important art of Surgery, and some modes of practice omitted in the *Encyclopædia*, are detailed, in a supplemental article, by Mr Cooper; and the present state of opinion, in the medical world, with respect to Vaccination, will be found in the article under that head. Other three articles upon the subjects of Bathing, Dietetics, and Food—the first by Dr Young, the two last by Dr Duncan, junior, complete the list of contributions in this department.

A number of articles have been assigned to the extensive department of *Arts and Manufactures;* and, though some of them refer to the *Encyclopædia* for such details as did not require any material alteration, the greater part may be described as complete treatises on their respective subjects. A simple enumeration of the more important will, therefore, suffice for the present purpose.

Among those relative to the Mechanical Arts and Manufactures are, Anchor-making, Assaying, Blasting, Block-Machinery, Boring, Brass-making, Cannon-making, Carpentry, Coining, Cotton-manufacture, Cutlery, Joinery, Iron-making, Lithography, Printing, Road-making, Steel Plate Printing, and Stone-Masonry,

including Stone-Cutting. The articles on Assaying and Coining were written by Mr Mushet; Carpentry partly, and Road-making by Dr Young; Boring and Cannon-making by Mr Cadell; Cotton-manufacture by Mr Bannatyne; Joinery and Stone-Masonry by Mr Tredgold; and Printing by Mr Stark; to whose promptitude and skill, in his professional connection with this work, the Editor feels himself in no small degree indebted.

The list of articles on the Arts and Manufactures connected with Chemistry, and other branches of General Physics, includes the following: Agriculture, Alum, Ammoniac-Sal, Baking, Bleaching, Brewing, Brick-making, Distillation, Gun-Powder, Horticulture, Lighting (treated under Gas-Lights and Lamps), and Wine-making. The first of these was written by Mr Cleghorn, an extensive Contributor in the departments of Statistics and Topography; the next seven by Dr Thomas Thomson; Horticulture by Mr Neill; and Gun-Powder and Wine-making by Dr Macculloch.

The last general head of the first division of this Outline, is that comprehending the articles relative to the *Philosophy of the Mind*, and *Political Philosophy*.

Most of the topics ranging under the first of these branches have been treated in the *Encyclopædia*; and, though several of them might be recast with advantage in another mould, this could not have been done in the present work, without the exclusion of subjects, in regard to which, greater additions have been made to the stock of positive knowledge. Articles have, however, been given on a few subjects, which seemed to require notice, either on account of the new lights which recent inquiries have reflected upon them, or of their practical utility.

The subject of Beauty, the discussion of which involves much of the theory of Taste, and the analysis of a numerous order of the most delightful emotions of which our nature is susceptible, is examined at considerable length, in an article written by Mr Jeffrey. The analytical part of it is preceded by a rapid, but discriminating survey of the doctrines maintained by preceding inquirers; and, though the theory which it is the author's object to establish, is substantially the same with that of Mr Alison, it is treated and illustrated in a form and manner so original and so striking, as to entitle this article to be characterized, as one of the most masterly and brilliant disquisitions in the whole compass of our philosophical literature.

Though Education is copiously treated in the *Encyclopædia*, the subject has been resumed in this work, with a view to a philosophical investigation of the great objects at which Education ought to aim, and the means of attaining them; an inquiry ably prosecuted in Mr Mill's article on that subject. The art of educating the Deaf and Dumb—one of the most pleasing results of this branch of philosophy, is fully explained in another article, written with his accustomed clearness and elegance, by Dr Roget.

Besides these articles, there is an examination of that new philosophy which pretends, not only to furnish an entirely original classification of our mental faculties and principles of action, but to point out certain external indications, in the bone of the head, of the state of energy and activity in which they exist. This is given, by the author just named, under the term Cranioscopy; a term which has been lately exchanged, by the disciples of this School, for that of Phrenology.

Political Philosophy has been hitherto but little attended to in the formation of Encyclopædias. Various circumstances, however, have of late years conspired so much to exalt the importance and interest of the subjects about which it is conversant, that they could not now be neglected in a work professing to furnish a general digest of useful knowledge, without exposing it to the charge of defectiveness in a most essential department. These subjects seem, indeed, to have peculiar claims to attention in such publications; for the inquirer in this department is but too often left to such information as can be procured in mere occasional and party productions;—in works where it is seldom attempted, either to pursue a scientific mode of discussion, or to reduce the scattered elements of knowledge into a systematic form. Hence the propriety of political investigations, in works planned for the purpose of methodizing and diffusing useful knowledge; where, though prejudice and predilection cannot of course be excluded, all the general topics of political science are far more likely to be treated in a philosophical spirit and form, than in most of the other vehicles of political information.

The defects of the *Encyclopædia Britannica* in almost all the branches of this department, left ample room, and, as the present Editor thought, a strong call to supply what was wanting there, in this publication; and he hopes it will be found, in one at least, if not all of these branches, far more complete than any work of

the kind existing; yet, without detriment to any other science or subject as to which information was here reasonably to be expected. The political articles contained in it may be considered as belonging to General Politics, to Political Economy, and to Political Arithmetic.

To the first head may be referred the articles Balance of Power, Government, Jurisprudence, Law of Nations, Liberty of the Press, and Prison Discipline; all of them, but the first, written by Mr Mill; whose contributions in this and the other departments where his assistance has been given, display a reach and depth of thinking, and a power of analytical reasoning, that must command the respect even of those who may sometimes be disposed to dispute his principles, or to dissent from his conclusions. Most of the great problems respecting the ends of government and legislation, and the means of preserving political, civil, and national rights, are discussed by him, in the articles just mentioned, in a form severely methodical, and in a spirit which seeks neither aid nor ornament from the artifices of rhetoric.

It is observed by M. Cuvier, in his *Historical Report* on the progress of certain branches of physical science in France, since the era of the Revolution, that the evils which the ruinous system of *Assignats* produced in that country, were, in some degree, compensated by the improvements in the arts to which it gave rise.[1] Compensations of a far higher order have, in this country, attended the evils occasioned by measures affecting the soundness of its Currency; for they have served to exercise the science of Political Economy in discussions, which have elicited new principles, afforded new explanations, and raised the truths which it unfolds to a degree of importance in the eyes of statesmen and legislators, of which the world is at length likely to experience the benefits. The space allotted to this science, in the plan of the present work, has been accordingly measured out, with a due regard to the interest which it has excited, and to its intrinsic utility; and here, also, the reader will receive the information which it presents to him, from contributions of eminent ability; some of them

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[1] "Elle a laisse à l'art du papetier des perfectionnemens durables, et sur-tout l'emploi de l'acide muriatique oxigéné pour le blanchiment de la pate. C'est meme à elle que l'on doit en grande parte le nouvel emploi des caractères stéréotypes, qui augmenteront les bienfaits de l'imprimerie, en faisant pénétrer les conceptions du génie jusque dans les plus pauvres chaumières." *Rapport Historique sur les Progrès des Sciences Naturelles*, p. 292.

written by those who, next to the immortal founder of the science, are universally considered as its greatest benefactors.

Taking them in alphabetical order, the following are the most important of these contributions: Banking, by Mr Buchanan; Banks for Savings, Beggar, Benefit Societies, Colony, by Mr Mill; Commerce, by Mr Lowe; Corn Laws, Cottage System, by Mr M'Culloch; Economists, by Mr Mill; Emigration, by Mr Buchanan; Exchange, by Mr M'Culloch; Funding System, by the late Mr Ricardo; Interest, Money, Political Economy, by Mr M'Culloch; Poor Laws, by the Reverend Mr Sumner; Population, by the Reverend Mr Malthus; and Taxation, by Mr M'Culloch.

It will appear from this enumeration, that the science of Political Economy is here examined as a whole, in a general treatise; while a number of articles are devoted to subordinate topics, requiring separate elucidation. As nothing was more wanted for the purposes of the student, than a succinct and systematic exposition of the leading doctrines of the science, the general article by Mr M'Culloch cannot fail to be regarded as a valuable addition to the means of diffusing the knowledge of its principles. His other articles are marked by the same clear and searching view of the whole field of inquiry, and the same depth and skill in the application of general principles, which eminently distinguish that treatise. They contain a forcible exposition of the new doctrines concerning rent, value, wages, and profits; while they also furnish full statements of the doctrines to which they are opposed. In copious references to the history of opinions and of measures, and in illustrative Tables, formed with the greatest attention to accuracy, they have recommendations of especial value in an Encyclopædia. The prejudices and clamours that have been opposed to the important and fruitful doctrine more particularly connected with the name of Mr Malthus, must be considered as greatly enhancing the value of the correct and comprehensive summary of the facts and reasonings by which it is established, here given, in their latest form, from his own pen. Closely connected with this subject is that of the article by Mr Sumner, which contains a clear and sound view of all the questions discussed in it. The articles in this department may be described generally, as furnishing a pretty complete view of all the great questions that have been agitated in modern times, relative to the creation, distribution, and con-

sumption of wealth ; the theory of, and trade in money ; the means employed for raising supplies for public expenditure ; the effects of subjecting the food of the people to artificial regulation ; the causes which regulate the increase and decrease of their numbers ; the causes and effects of pauperism and mendicity ; and the expedients that have been adopted or proposed for the relief, removal, or mitigation of those evils.

In the branch of Political Arithmetic, there are two articles, by the able Calculator already mentioned as the author of the article on Annuities. The first, on Bills of Mortality, explains the history, formation, and uses of these important registers ; the other, on the Law of Mortality, explains the principle which governs the waste of human life, and furnishes the means of calculating the probable length of its duration at any given age.

After the primary division of the Sciences and Arts, the three connected provinces of GEOGRAPHY, STATISTICS, AND TOPOGRAPHY, occupy the largest portion of the present work. The observations and inquiries made during the last twenty years have produced a great accession of new information in all of them. During that period, the obscure districts of central Africa, the interior regions and vast rivers of the American continent, the numerous islands which compose the two new divisions of the world in the Indian and Pacific Oceans, and the icy seas which involve the Poles, have been visited by various expeditions of discovery, which have contributed essentially to rectify and extend our geographical knowledge. During that period too, great changes have taken place in the political geography and condition of states. Many transfers of territory and dominion have been witnessed in the old world, and a number of independent communities have arisen in the most depressed quarters of the new ;—in quarters, where liberty, it is to be hoped, will ere long be established upon a solid basis, and fresh scenes of exertion opened to the expansive and illimitable powers of British industry and enterprise. The means of information respecting the internal and relative circumstances of nations, have also been much enlarged during that period. It has produced two authoritative enumerations of the population of our own country ; and a variety of publications, domestic and foreign, replete with instructive details in all the branches of statistical inquiry. These various considerations seemed to require,

that a considerable portion of the work should be devoted to this useful and interesting class of subjects.

All the great divisions of the Globe recognized by the older geographers, excepting Asia, which is largely surveyed in the *Encyclopædia*, together with the new divisions of Australasia and Polynesia, have been treated in general articles; embracing the latest information belonging to such heads. Another general article has been employed upon the history of discovery in the Polar Seas, and the problem as to the existence of a northern passage to the Pacific Ocean;—a problem which has acquired great additional interest, from the noble attempts lately made by this country to solve it, and to subject the terrors of the arctic zone to her courage and her genius.

In the general article on Europe, by Mr Maclaren, there is a comparative view of the extent, population, and resources of all the different European states. The account of Africa, by Mr Murray, contains much learned and ingenious inquiry as to the knowledge of it possessed by the Ancients, and the Arabian writers; as well as concerning the long agitated question of the termination of the Niger;—a question happily decided since that article was written; as the reader will find, by turning to the interesting particulars detailed under the word Zaire. To the writer of these particulars, himself a distinguished promoter of geographical discovery, the work is indebted for three of the general articles above alluded to; those namely on Australasia, Polynesia, and the Polar Seas.

Besides the general comparative view of the European States, there are separate articles on most of them; in the composition of which, the greatest attention has been paid, by their respective writers, to all the latest and best sources of information. Exclusive of those which relate to the British Empire, the most important are the articles on Austria and France, by Mr Lowe; those on Germany, the Netherlands, Portugal, Prussia, and Russia, by Mr Jacob; those on Greece, and the Ionian Islands, by Mr Maclaren; and the very interesting and instructive article on Spain, by the Reverend Mr Blanco White; himself a native of that unfortunate Country.

With respect to the British Empire, the Statistics of its three great members—England, Ireland, and Scotland, are copiously detailed under these, and some other

heads; and there are, besides, Topographical articles on each of their respective counties. In the numerous *Reports* presented to Parliament, the British Statist has means of information, no where possessed in a form so authentic and satisfactory, in regard to any other Country. Great use has been made of these invaluable documents by the intelligent writers of the articles alluded to; of which, that on England, by Mr Lowe, is necessarily the most extensive and various.[1] The Fisheries form a separate article, written by Mr Barrow; and various other branches of national industry have been already mentioned, as the subjects of articles, in the list of those regarding Arts and Manufactures. The Navy too makes a distinct head of inquiry; under which is comprised an account of every thing appertaining to our ships of war, as well as to the appointment, rank, duties, and pay of those employed in them; forming, with the articles on the office of Lord High Admiral, on the Court of Admiralty, on the Dock-Yards, and on the Telegraph, a far more correct and complete view of this great bulwark of the nation, and favourite instrument of her power, than is to be found in any other publication.

The County articles contain much useful information concerning rural affairs, and the progressive numbers, and employments of the people. Two topographical articles, of a different kind, are employed on two Scottish national works,—the Caledonian Canal, and the Bell-Rock Light-House; both written by an experienced Engineer, Mr Stevenson.

Next to Europe and its Islands, the vast regions of the American Continent have been most largely described in this work. Under the term United States, there is an excellent general view of these great and prosperous communities, written by Mr Maclaren. The other articles of most importance are those on Brazil, Buenos Ayres, Canada, and the Caraccas, by Mr Buchanan; and those on the Floridas, New Granada, Guatimala, Guiana, Louisiana, Mexico, and Peru, by Mr Jacob; who has carefully and skilfully availed himself of the many valuable details contained in the publications of Baron Humboldt, and of some other sources of information

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[1] The *Population* of the British Empire, as ascertained by the Census of 1821, is given under the article Population, among the ADDENDA, subjoined to the sixth volume. In the Table annexed to the article *Taxation*, Vol. VI. p. 644, there will be found a much later view and analysis of the *Revenue* of the Empire, than is contained in the article on *England*.

but little known or examined by English readers. The articles on New Granada, Mexico, and Peru, may be particularly mentioned, as furnishing a very instructive and interesting view of those magnificent regions.

Several articles have been given on those parts of Asia and its Islands, as to which any new information of importance has been laid before the Public. Of these, the only one requiring particular notice is the account of China, by Mr Barrow. Notwithstanding the voluminous publications of the Jesuits, the era of accurate information concerning this vast Empire, can only be said to have commenced with Lord Macartney's embassy to Pekin. It was only then, in particular, that correct ideas begun to be formed of the structure of its extraordinary language; of which, the knowledge that has been since acquired by several of our countrymen, has enabled them to sift its mysterious literature, and to dispel many illusions which had hitherto prevailed. One of the most curious and valuable portions of the present article, is that employed in explaining the nature of this language, and the construction of its written character; but the author has taken a comprehensive view of the whole field of inquiry included in his subject; illuminating every part of it with the information derived from a thorough knowledge of all the published authorities, enlarged and rectified by personal observation.

With the exception of a general survey of the Barbary States, by Mr Murray, the only African country forming a separate article is Egypt. This article comprises the substance of what is to be found in the latest publications concerning that country; but is far more remarkable, from containing, besides other learned inquiries, the rudiments of a Hieroglyphical Vocabulary; founded upon the analysis of the famous triple inscription on the stone of Rosetta, now deposited, among some other precious remains of ancient Egypt, in the British Museum. It was in this article, indeed, that Dr Young first gave to the Public an extended view of the results of his successful interpretation of the hieroglyphical characters used in that inscription; unquestionably one of the most remarkable achievements of modern scholarship, and which has furnished a key to the mysteries of Egyptian literature, sought for in vain by the learned of the ancient world.

The additions made to History and Biography have been limited to accounts

of recent events, and mostly of recent lives. To have reconsidered portions of History already examined in the *Encyclopædia*, whatever defects there might be in the materials, or mode of treating them; or, to have attempted any material enlargement of the Biographical department, with respect to distant ages, would have occasioned encroachments upon the space necessary for inquiries more strongly called for by the objects of the work. The historical information is given chiefly in connection with the geography and statistics of the different states; and may be described, generally, as embracing all the great events and transactions of the last twenty years. For the particular history of the European states, during that period, the reader must turn to the articles under their respective names; but, under the head of Great Britain, he will find a general view of the events and results of the mighty contest in which the greater powers were engaged, from the period of the rupture of the treaty of Amiens, down to the memorable era of the battle of Waterloo. With respect to the other quarters of the world, there is an account of our wars in India, under that word; of the late war with the United States, in the general historical article just mentioned; and of the revolutions and subsequent occurrences in the Spanish American Colonies, in the articles on these countries, already noticed in this Outline.

Though some Biographical articles have been inserted, for the purpose of supplying what seemed palpable omissions in the *Encyclopædia*, the greater part are accounts of persons who have died during the last thirty years. The number amounts in all to about one hundred and sixty; and the subjects of them have been selected, for the most part, on account of their eminence in Science or Literature.

Of these articles, a large proportion of such as relate to men of science have been contributed by Dr Young. Valuable in many respects, as accounts of such men, written by one so deeply versed in all that they have done and taught, could not fail to be, they are recommended in a particular manner, for the purposes of a work of reference, by their accurate bibliographical notices and lists of even the smallest pieces, written by the persons whom they commemorate. Dr Young's assistance in this department was not confined to any particular class of lives; and his account of Porson, whose acquaintance he enjoyed "for the last twenty years of his life," is perhaps the most interesting and discriminating that has yet been published of that illustrious scholar. The work is enriched with several other accounts of

distinguished men, derived from long personal knowledge of them, and other sources of genuine information not accessible to every eye. Among these may be mentioned the account of Dr Adam, by Professor Pillans; of Dr Adam Ferguson and Mr Home, by the Reverend Dr Lee; of Mr Fox, by Mr Allen; of Professor Playfair, by Mr Jeffrey; of Mr Rennie, by Mr Barrow; and of Mr Watt, obtained from a quarter which justifies the Editor in pointing it out, as the most complete and authentic yet published of that distinguished benefactor of the useful arts.

The list of articles not properly belonging to any of the preceding departments, and which may, therefore, be ranked in the class of MISCELLANEOUS LITERATURE, is not very numerous. It however embraces several, on subjects of considerable interest, which have either been omitted in the *Encyclopædia*, or have not been treated there in a suitable manner, and with the advantages of the knowledge now possessed in regard to them. Such are the articles on the Fine Arts, Bibliography, Chivalry, the Drama, Languages, Romance, and War.

The object of the able article, written by Mr Hazlitt, under the first of these heads, is to point out the principle of excellence in the Arts; particularly in those of Painting and Sculpture; and to inquire into their progress, and the means proposed for their advancement in this country. Great and valuable additions have, of late years, been made to the stock of knowledge, in that branch of philological learning which relates to the history and affinities of Languages. The discoveries in this field have opened up sources of information as to the early history of the human race, which no other researches or monuments could possibly supply. It is to the philologers of Germany that this branch of learning is more especially indebted; and the reader will find the results of their inquiries, and of those of our countrymen who have seconded their labours, in the elaborate article on Languages, written by Dr Young. Of the articles on the interesting subjects of Chivalry and Romance, and on the more extensive and classical theme of the Drama, it is enough to say, that they are the productions of Sir Walter Scott. If they cannot increase, they certainly will not detract from the lustre of that celebrated name, in whatever literary capacity it may be pronounced. The article on War, by Major Hamilton Smith, contains a skilful exposition of the rules applicable to all the different kinds

of military operations; with copious illustrations from the great movements and events of the late continental campaigns.

The Editor cannot conclude this Outline of the contents of the work, without some further mention of those Discourses on the History of the Sciences, from which it derives such peculiar recommendations.[1]

The striking figure used by Lord Bacon, in mentioning the want of a general history of philosophy, to illustrate the nature and magnitude of that want, is known to all the world. Much has been done, since his time, to supply the information on this head which he thought so indispensible to the completion of the Circle of Learning; but very little has been done to furnish it in a form calculated to promote its general diffusion. The brilliant Sketch contained in D'Alembert's Discourse prefixed to the *Encyclopédie*, forms but a small part of that celebrated performance; the greater part of it being occupied with a theoretical view of the origin of the sciences, and of their encyclopedical arrangement. Though sufficient for the display of his own various attainments, the scale of his historical notices was much too limited to admit of any satisfactory views of the opinions, even of the small number of "those great *lights of the world* by whom the torch of science has been successively seized and transmitted." On the other hand, the works of the professed Historians of Philosophy are much too extensive and minute for general perusal. The proper medium seems to have been attained, in the noble Discourses by Mr Stewart and Mr Playfair, prefixed to these volumes. Nor is this their only excellence in point of plan. Those who are best acquainted with, and most competent to decide upon the merits of the other

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[1] Mention has been already made of the Discourse on the History of *Chemistry*, written by Mr Brande; and the general objects of the whole, and the order in which it was proposed they should appear in the work, have been detailed in the Original *Advertisement*. That order was afterwards altered, conformably to an arrangement mentioned in a subsequent *Advertisement*, prefixed to the *third* volume. It was at one time imagined, that when the work came to be bound up, the Discourses of Mr Stewart and Mr Playfair might be placed in its successive volumes, in the order of their Parts; but their inequalities in point of size have rendered it necessary, that they should remain in the order in which they were published.

Mr Stewart alludes (*Dissertation*, Part First, p. 12) to a translation of D'Alembert's *Discourse* as intended to be annexed to those prefixed to this work; but this part of the plan was, on due consideration, abandoned as unnecessary.

histories of philosophy, will perhaps be the most ready to acknowledge the superior skill with which the consecutive heads of inquiry have been arranged in these Discourses. They will not be less ready to acknowledge, that the originality and depth of the reflections and reasonings contained in them, is as conspicuous as the majesty and beauty of the language in which they are expressed.

That these splendid Discourses have not been completed, must be matter of regret to the Public, as it certainly is to those more immediately connected with this work. The completion of Mr Playfair's, it is well known, was prevented by his death.[1] The fine parallel between Newton and Leibnitz, which occupies the last pages of what has been printed of the *Second Part* of his Discourse, was corrected only a few days before that event; and it shows how strong and clear, to its very extinction, was that light, which had so long diffused its radiance over the paths of science. Mr Stewart's plan has been fully executed, in so far as concerns the history of Metaphysical Knowledge; but that of Moral and Political Philosophy during the eighteenth century, at the commencement of which, the *First Part* of his Discourse closes, is unfortunately wanting. He has himself addressed the Public on this subject, in the *Advertisement* prefixed to his Second Part;[2] but, notwithstanding the demands upon his time there alluded to, he would not have failed to attempt the accomplishment of his design, had his health been sufficiently stable to allow him to fulfil his own views and wishes in regard to it.

In closing this Outline, the Editor begs, that no one will ascribe the terms of commendation which occasionally occur in it, to any presumptuous idea, that they could be of any consequence, either to those to whom they apply, or to the Public. He conceived that it was his duty to give some account of the plan and contents of the work; and in doing so, he has only exercised the privilege allowed to the humblest historian, of representing the persons and things that come under his review, in the light in which they appear to his own understanding.

After the full view that has been given of the work, and the principles upon which it has been formed, there remain only a very few points requiring any farther remark or explanation.

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[1] See the *Advertisement* prefixed to the *Fourth* Volume of this work.

[2] See Volume *Fifth* of this work.

One of these is the apparent disproportion between the space allotted to the last, as compared with that occupied by the first half of the Alphabet. With respect to this, the Editor must observe, that the Letters in that half, with one or two exceptions, are not nearly so productive of articles as those in the first half; that several of them are almost entirely barren; that a considerable part of each volume, except the last, is occupied with a preliminary Discourse; and finally, that it is scarcely possible to adjust the earlier parts of a work of this kind to a scale exactly suited to the whole.

It may also be thought, that the articles are sometimes of a disproportionate length; and the Editor certainly does not mean to say, that every subject occupies exactly that space, which a due regard to all the circumstances regulating the plan of the work would prescribe. In truth, if an Encyclopædia is to be composed of original articles, written by men of eminence, who have made a particular study of the subjects upon which they are required to write, or who have particular means of information concerning them, it will always be found difficult, if not impossible, to limit each contribution to the space required by the general plan. But the Editor makes this observation, rather to obviate cavils, than as thinking any apology of the kind much called for in relation to the present work; for, though distinguished in an eminent degree by the literary rank of its Contributors, he is inclined to think, that it is less liable to criticism, in the particular alluded to, than any similar work that could be named.

Another point requiring some explanation, is the want of several articles, to which there are references in the work. This has arisen, partly from disappointments incident to every undertaking of the kind, and from which no diligence, however great, will ever secure an exemption; and partly from discovering, as the work advanced, that the subjects referred to could not be treated, without excluding others of more interest and importance. They who are disposed either to censure omissions, or to object to particular articles as superfluous, would do well to recollect, that in order to form a fair judgment, it would be necessary, in every such case, to attend to all the particulars requiring to be considered in adjusting the plan of the work; that the formation of such a plan is evidently a business of *selection*, and consequently of discretionary choice; and, that an Editor's arrangements are liable to be varied by circumstances which he cannot possibly control.

The plan of announcing the names of Contributors, in connection with their respective articles, was first adopted, and was pretty extensively followed in the French *Encyclopédie;* though not always, it would appear, with perfect good faith; for towards its close, in particular, it is said to have been a common stratagem, to announce certain articles as the productions of authors predeceased.[1] In no work of the kind has this plan been so steadily and extensively followed as in the present *Supplement;* and there can be no doubt, that it has contributed essentially to its character and success. It was a favourite object with its intelligent Projector, and the Editor readily entered into his views, being thoroughly satisfied that the Public would approve and profit by them. Yet he must say, that it is a plan attended with some embarrassments; and likely always to stand somewhat in the way of that rapidity and regularity in the publication of such works, which is so much desired both by Booksellers and by the Public; as well as to add considerably to the difficulty of adjusting their contents to a regulated scale.

The time is long past when it was thought necessary to recommend works of this kind by a formal exposition of their utility. Their numbers, and the encouragement given to them, afford a strong proof, both of the favourable state of the human mind in regard to the desire for information, and of the means of administering to that desire in an efficient manner. Works of fiction, and periodical miscellanies of various kinds, are the only other publications which rival Encyclopædias in the extent of their circulation; but the success of these must be allowed to be greatly owing to the love of amusement, to the relish for literary novelties, and to the feelings connected with political discussion; whereas Encyclopædias have no such stimulants, and if successful at all, they must owe their success entirely to the means they furnish for informing and enlightening the understanding. Their utility, in a word, seems sufficiently proved, by the mere fact of their existence and extensive dissemination.

The contrary opinion has, however, been countenanced by names of great distinction in our Literature, and appears still to linger among some of the learned.

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1 ——" C'étoit alors la tactique de mettre sur le compte des morts les diatribes les plus hardies. *Biographie Universelle*, Tom. X. Art. Damilaville.

"Mr Gray," says Mr Mathias, in the *Postscript* to his edition of the works of that eminent Poet and Scholar, "always considered, that the Encyclopædias, and Universal Dictionaries of various kinds, with which the world now abounds so much, afforded a very unfavourable symptom of the age in regard to its literature; as no real or profound learning can be obtained but at the fountain-head. Dictionaries like these, as he thought, only served to supply a fund for the vanity, or for the affectation of general knowledge; or for the demands of company and of conversation; to which, he said, such works were fully competent."[1] No British Encyclopædia had appeared before Mr Gray's death, of any considerable extent, or which, in point of execution, could be said to rank above the level of mere compilation; but the French *Encyclopédie*, which had been in the course of publication for a long time, and was completed some years before that event, had early attracted the notice of the learned throughout Europe; and, with all its defects, it unquestionably contains much, that might have occurred to Mr Gray, as fitted to minister to intellectual exercises of a higher order, than those to which he so arbitrarily limited the reach of such undertakings. There cannot be a doubt, besides, that much was done by our earlier Encyclopædias, limited as their scale was, to render knowledge more generally accessible and acceptable, and to give it a wider diffusion among the body of the people, than it had obtained before. The success of these works ought, therefore, to have been hailed and commended as a favourable, not an unfavourable symptom of the intelligence of the age. The passage just quoted would, indeed, warrant the suspicion, that Mr Gray considered knowledge as the exclusive appanage of the learned, and that the Republic of Letters must be viewed as in an unsound state, when the Citizens are admitted to any communion with their Superiors.

It is at any rate clear, that this eminent person had formed a very incorrect idea of the nature and ends of the publications which he censured. Encyclopædias may bring the means of liberal knowledge—of knowledge, accurate, and well digested, within the reach of thousands who would never otherwise have possessed such means, in so desirable a form. This is their object, their office, and their praise; and no one ever supposed, that they were to supersede the necessity of recurring to

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[1] Gray's *Works*, by Mathias, Vol. II. p. 598.

other sources of information, upon subjects where "profound learning" is wished to be attained. Nor is there any risk of such works intercepting the resort to others, where the desire for information exists in the requisite degree of ardour. They may stimulate curiosity, and nourish a love for study, in minds that might otherwise remain passive or inert; but they will never induce a feeling of satisfaction with deficient information, where it is incomplete, in minds that would have otherwise grasped at larger and richer acquisitions.

There never was, at any time, but one objection specially applicable to this class of publications;—that, namely, of breaking the Sciences into fragments, scattered fortuitously among the Letters of the Alphabet; and it must ever reflect credit on the *Encyclopædia Britannica*, to have been the first that fully remedied a defect which had been deemed inseparable from such undertakings. Since that period, some of the most valuable of the systematic treatises, with which the Sciences have, in this Country, been enriched, have appeared in Encyclopædias; and have in that way obtained a far wider and more beneficial circulation than they could ever otherwise have reached.

These works, indeed, have a cosmopolitan character, which, in an improving state of society, recommends them equally to every rank, from the Mechanic to the Peer. The history of Letters affords no example of any association for the advancement of the Sciences, so truly useful, and so free from all paltry cabals, and degrading influences, as those through which such publications are formed. Nor are there any other undertakings of a literary nature, in which the talents of so many individuals of different parties, and of all varieties of intellectual pursuit and attainment, can be so happily and efficiently combined, in the common cause of Science and Learning.

*Edinburgh, March*, 1824. MACVEY NAPIER.

# SIGNATURES

TO THE

# ARTICLES AND TREATISES

CONTAINED IN THIS WORK.

---

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VVV. Major Charles Hamilton Smith, Guernsey.

WWW. David Irving, LL.D. Edinburgh.

XXX. D. F. Arago, Member of the Royal Institute of France, Paris.

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*A. L. Thomas Young, M. D. F. R. S. Secretary to the Board of Longitude, and Corresponding Member of the Royal Institute of France.

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* This signature is affixed to those Articles which Dr Young contributed to the *last* half volume of this work. His other Articles are distinguished by a varying signature, always composed of *two different letters.*

# ADVERTISEMENT.

The Encyclopædia Britannica forms a General Dictionary, not only of Arts and Sciences, but of every branch of Human Knowledge. It was the first work of this class which aspired to embrace all the departments of Learning, and it was also the first which gave the example of a connected and coherent method of treating the Sciences. In its plan, it has received the decided approbation of most of those who have turned their attention to the subject; and as the work has now gone through *Five* extensive editions, it cannot be doubted, that, both in arrangement and execution, it has met the general approbation of the public.

As there is no material difference in the text of the two last editions, the present work is thus rendered equally applicable to both. It was undertaken with the view of supplying omissions,—of remedying the defects of imperfect execution,—and of exhibiting the Arts and Sciences in their latest state of improvement. It will also afford an opportunity of continuing the leading Historical articles to the present time,—of adapting the Geographical and Statistical information to the altered state of the world;—and, in short, of reviewing and augmenting every department of knowledge embraced by the Encyclopædia.

The utility of such a work must appear abundantly obvious. By means of it, the *Encyclopædia Britannica* will be rendered more complete as a Book of Reference, and raised to a level with the improved knowledge and spirit of the age. Though more immediately connected with the two last editions, it must also prove a valuable sequel to the *Third*; and indeed the nature of the work is such, as to extend its utility to a much wider circle; as it will of itself afford a comprehensive view of the progress and present state of all the more interesting departments of Human Knowledge.

This SUPPLEMENT will extend to Five Volumes. In the *General Preface*, to be given on its completion, the Editor will explain, at some length, the views by which he has been guided, in the arduous task of selecting and adjusting its Articles and Treatises; and he hopes, with some confidence, to be able to show, that to have confined the Work within narrower limits, would have materially interfered with every useful object proposed by its publication. In the meantime he may observe, that the same number of Supplementary Volumes was thought necessary to complete the French *Encyclopédie,*—a work planned, conducted, and written by the most eminent authors of the country which produced it.

The *Dissertation* prefixed to this Half-Volume forms the first of a series of similar Discourses, with one of which each Volume of the Work will commence; and whose object is, to exhibit a rapid view of the progress made since the Revival of Letters, first, in those branches of knowledge which relate to MIND, and next, in those which relate to MATTER. In so far as regards the Philosophy of Mind, and its kindred branches, this historical sketch is brought down, in the present *Dissertation*, to the beginning of the last century; and the inquiry will be concluded in another Dissertation, to be prefixed to the *Third* Volume. The *Second* Volume will commence with a similar view of the progress of the Mathematical and Physical Sciences, during the same period, by PROFESSOR PLAYFAIR; who will in like manner conclude the history of these sciences in another Discourse, to be given with the *Fourth* Volume. This series will be closed by a Dissertation on the History of Chemical Discovery, and Chemical Theory, by MR WILLIAM THOMAS BRANDE, to be prefixed to the *Last* Volume.

Of the particular merits of that portion of this historical survey with which the present Volume is enriched, this is not the place to speak; but of these Discourses generally, the Editor may here be permitted to observe, that they form a novel feature in the Encyclopædias of this Country; and, that every Encyclopædia must be in so far incomplete, which does not furnish a connected view of the Progress of the Sciences, as well as the details of their Present State.

The Editor has much pleasure in enumerating the names of those who have engaged to honour the Work with their co-operation:

Reverend Archibald Alison, LL.B. F.R.S. L. & E.
John Aiken, M. D. F. L. S.
Thomas Allan, Esq. F. R. S. L. & E.
John Barrow, Esq. F. R. S. one of the Secretaries of the Admiralty.
H. D. Blainville, M.D. Professor of Zoology and Comparative Anatomy, Paris.
Will. Tho. Brande, F. R. S. L. & E. Professor of Chemistry to the Royal Institution of London.
Mr David Buchanan.
William Archibald Cadell, Esq. F.R.S. L.&E.
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John Colquhoun, Esq. Advocate.
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Andrew Duncan, Junior, M. D. F. R. S. E. Professor of Medical Jurisprudence in the University of Edinburgh.
John Graham Dalyell, Esq. Advocate.
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William Elford Leach, M. D. F. L. S. Zoologist to the British Museum.
William Lawrence, Esq. F. R. S. Surgeon, London.
Joseph Lowe, Esq.
Charles Mackenzie, Esq. F. R. S.—L. S.
Robert Muschet, Esq. Royal Mint, London.
James Mill, Esq. London.
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Mr Sylvester, Derby.
Mr Stoddart, London.
William Stevenson, Esq. London.
Thomas Thomson, M.D. F.R.S. L. and E.
John Taylor, Esq. Civil Engineer, London.
Rev. William Turner, Newcastle.
William Wallace, F. R. S. E. one of the Professors of Mathematics, Royal Military College, Sandhurst.

It only remains to be mentioned, that, at the end of each Volume, there will be given a Key to the marks annexed to its Articles and Treatises; by

which means, the purchasers of the Work will be regularly informed of the names of those by whom they were written. This plan, originally adopted in the French *Encyclopédie*, seems eminently calculated to increase the confidence of the public in such undertakings.

MACVEY NAPIER.

*Edinburgh, November* 1815.

# DISSERTATION FIRST:

EXHIBITING A GENERAL VIEW

OF THE

# PROGRESS OF METAPHYSICAL, ETHICAL, AND POLITICAL PHILOSOPHY,

SINCE THE REVIVAL OF LETTERS IN EUROPE.

By DUGALD STEWART, Esq. F. R. SS. Lond. & Edin.

HONORARY MEMBER OF THE IMPERIAL ACADEMY OF SCIENCES AT ST PETERSBURGH;

MEMBER OF THE ROYAL ACADEMY OF BERLIN,

AND OF THE AMERICAN PHILOSOPHICAL SOCIETY HELD AT PHILADELPHIA;

FORMERLY PROFESSOR OF MORAL PHILOSOPHY IN THE UNIVERSITY

OF EDINBURGH.

# PREFACE

TO THE

# FIRST DISSERTATION,

## CONTAINING SOME CRITICAL REMARKS ON THE DISCOURSE PREFIXED TO THE FRENCH ENCYCLOPE'DIE.

When I ventured to undertake the task of contributing a Preliminary Dissertation to these Supplemental Volumes of the *Encyclopædia Britannica*, my original intention was, after the example of D'Alembert, to have begun with a general survey of the various departments of human knowledge. The outline of such a survey, sketched by the comprehensive genius of Bacon, together with the corrections and improvements suggested by his illustrious disciple, would, I thought, have rendered it comparatively easy to adapt their intellectual map to the present advanced state of the sciences; while the unrivalled authority which their united work has long maintained in the republic of letters, would, I flattered myself, have softened those criticisms which might be expected to be incurred by any similar attempt of a more modern hand. On a closer examination, however, of their labours, I found myself under the necessity of abandoning this design. Doubts immediately occurred to me with respect to the justness of their logical views, and soon terminated in a conviction, that these views are radically and essentially erroneous. Instead, therefore, of endeavouring to give additional currency to speculations which I conceived to be fundamentally unsound, I resolved to avail myself of the present opportunity to point out their most important defects;—defects which, I am nevertheless very ready to acknowledge, it is much more easy to remark than to supply. The critical strictures which, in the course of this discussion, I shall have occasion to offer on my predecessors, will, at the same time,

account for my forbearing to substitute a new map of my own, instead of that to which the names of Bacon and D'Alembert have lent so great and so well-merited a celebrity; and may perhaps suggest a doubt, whether the period be yet arrived for hazarding again, with any reasonable prospect of success, a repetition of their bold experiment. For the length to which these strictures are likely to extend, the only apology I have to offer is the peculiar importance of the questions to which they relate, and the high authority of the writers whose opinions I presume to controvert.

Before entering on his main subject, D'Alembert is at pains to explain a distinction, which he represents as of considerable importance—between the Genealogy of the sciences, and the Encyclopedical arrangement of the objects of human knowledge.[1] "In examining the former," he observes, "our aim is, by remounting to the origin and genesis of our ideas, to trace the causes to which the sciences owe their birth; and to mark the characteristics by which they are distinguished from each other. In order to ascertain the latter, it is necessary to comprehend, in one general *scheme*, all the various departments of study; to arrange them into proper classes; and to point out their mutual relations and dependencies." Such a *scheme* is sometimes likened by D'Alembert to a map or chart of the intellectual world; sometimes to a Genealogical[2] or Encyclopedical Tree, indicating the manifold and complicated affinities of those studies, which, however apparently remote and unconnected, are all the common offspring of the human understanding. For executing successfully this chart or tree, a philosophical delineation of the natural progress of the mind may (according to him) furnish very useful lights; although he acknowledges that the results of the two undertakings cannot fail to differ widely in many instances,—the laws which regulate the generation of our ideas often interfering with that systematical order in the relative arrangement of scientific pursuits, which it is the purpose of the Encyclopedical Tree to exhibit.[3]

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1 "Il ne faut pas confondre l'ordre Encyclopédique des connoissances humaines avec la Génealogie des Sciences." Avertissement, p. 7.

2 It is to be regretted, that the epithet *Genealogical* should have been employed on this occasion, where the author's wish was to contradistinguish the idea denoted by it, from that historical view of the sciences to which the word *Genealogy* had been previously applied.

3 The true reason of this might perhaps have been assigned in simpler terms by remarking, that the order of invention is, in most cases, the reverse of that fitted for didactic communication. This observation applies not only to the analytical and synthetical processes of the *individual;* but to the progressive improvements of the *species,* when compared with the arrangements prescribed by logical method, for conveying a knowledge of them to students. In an enlightened age, the sciences are justly considered as the basis of the arts; and, in a course of liberal education, the former are always taught prior to the latter. But, in the order of invention and discovery, the arts preceded the sciences. Men measured land before they studied speculative geometry;

In treating of the first of these subjects, it cannot be denied that D'Alembert has displayed much ingenuity and invention; but the depth and solidity of his general train of thought may be questioned. On various occasions, he has evidently suffered himself to be misled by a spirit of false refinement; and on others, where probably he was fully aware of his inability to render the theoretical chain complete, he seems to have aimed at concealing from his readers the faulty links, by availing himself of those epigrammatic points, and other artifices of style, with which the genius of the French language enables a skilful writer to smooth and varnish over his most illogical transitions.

The most essential imperfections, however, of this historical sketch, may be fairly ascribed to a certain vagueness and indecision in the author's idea, with regard to the scope of his inquiries. What he has in general pointed at is to trace, from the theory of the Mind, and from the order followed by nature in the developement of its powers, the successive steps by which the curiosity may be conceived to have been gradually conducted from one intellectual pursuit to another; but, in the execution of this design (which in itself is highly philosophical and interesting), he does not appear to have paid due attention to the essential difference between the history of the human species, and that of the civilized and inquisitive individual. The former was undoubtedly that which principally figured in his conceptions; and to which, I apprehend, he ought to have confined himself exclusively; whereas, in fact, he has so completely blended the two subjects together, that it is often impossible to say which of them was uppermost in his thoughts. The consequence is, that, instead of throwing upon either those strong and steady lights, which might have been expected from his powers, he has involved both in additional obscurity. This indistinctness is more peculiarly remarkable in the beginning of his Discourse, where he represents men in the earliest infancy of science, before they had time to take any precautions for securing the means of their subsistence, or of their safety,—as philosophising on their sensations,—on the existence of their own bodies,—and on that of the material world. His Discourse, accordingly, sets out with a series of Meditations, precisely analogous to those which form the introduction to the philosophy of Descartes; meditations which, in the order of time, have been uniformly posterior to the study of external nature; and which, even in such an age as the present, are confined to a comparatively small number of recluse metaphysicians.

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and governments were established before politics were studied as a science. A remark somewhat similar is made by Celsus, concerning the history of medicine: "Non medicinam rationi esse posteriorem, sed post medicinam inventam, rationem esse quæsitam."

Of this sort of *conjectural* or *theoretical* history, the most unexceptionable specimens which have yet appeared, are indisputably the fragments in Mr Smith's posthumous work on the History of Astronomy, and on that of the Ancient Systems of Physics and Metaphysics. That, in the latter of these, he may have occasionally accommodated his details to his own peculiar opinions concerning the object of Philosophy, may perhaps, with some truth, be alleged; but he must at least be allowed the merit of completely avoiding the error by which D'Alembert was misled; and, even in those instances where he himself seems to wander a little from the right path, of furnishing his successors with a thread, leading by easy and almost insensible steps, from the first gross perceptions of sense, to the most abstract refinements of the Grecian schools. Nor is this the only praise to which these fragments are entitled. By seizing on the different points of view from whence the same object was contemplated by different sects, they often bestow a certain degree of unity and of interest on what before seemed calculated merely to bewilder and to confound; and render the apparent aberrations and caprices of the understanding, subservient to the study of its operations and laws.

To the foregoing strictures on D'Alembert's view of the origin of the sciences, it may be added, that this introductory part of his Discourse does not seem to have any immediate connection with the sequel. We are led, indeed, to expect, that it is to prepare the way for the study of the Encyclopedical Tree afterwards to be exhibited; but in this expectation we are completely disappointed;—no reference to it whatever being made by the author in the farther prosecution of his subject. It forms, accordingly, a portion of his Discourse altogether foreign to the general design; while, from the metaphysical obscurity which pervades it, the generality of readers are likely to receive an impression, either unfavourable to the perspicuity of the writer, or to their own powers of comprehension and of reasoning. It were to be wished, therefore, that, instead of occupying the first pages of the *Encyclopédie*, it had been reserved for a separate article in the body of that work. There it might have been read by the logical student, with no small interest and advantage; for, with all its imperfections, it bears numerous and precious marks of its author's hand.

In delineating his Encyclopedical Tree, D'Alembert has, in my opinion, been still more unsuccessful than in the speculations which have been hitherto under our review. His veneration for Bacon seems, on this occasion, to have prevented him from giving due scope to his own powerful and fertile genius, and has engaged him in the fruitless task of attempting, by means of arbitrary definitions, to draw a veil over incurable defects and blemishes. In this part of Bacon's logic, it must, at the same time, be owned, that there is something peculiarly captivating to the fancy; and, accordingly, it has united in its favour the suffrages

of almost all the succeeding authors who have treated of the same subject. It will be necessary for me, therefore, to explain fully the grounds of that censure, which, in opposition to so many illustrious names, I have presumed to bestow on it.

Of the leading ideas to which I more particularly object, the following statement is given by D'Alembert. I quote it in preference to the corresponding passage in Bacon, as it contains various explanatory clauses and glosses, for which we are indebted to the ingenuity of the commentator.

"The objects about which our minds are occupied, are either spiritual or material, and the media employed for this purpose are our ideas, either directly received, or derived from reflection. The system of our direct knowledge consists entirely in the passive and mechanical accumulation of the particulars it comprehends; an accumulation which belongs exclusively to the province of Memory. Reflection is of two kinds, according as it is employed in reasoning on the objects of our direct ideas, or in studying them as models for imitation.

"Thus, Memory, Reason, strictly so called, and Imagination, are the three modes in which the mind operates on the subjects of its thoughts. By Imagination, however, is here to be understood, not the faculty of conceiving or representing to ourselves what we have formerly perceived, a faculty which differs in nothing from the memory of these perceptions, and which, if it were not relieved by the invention of signs, would be in a state of continual exercise. The power which we denote by this name has a nobler province allotted to it, that of rendering imitation subservient to the creations of genius.

"These three faculties suggest a corresponding division of human knowledge into three branches, 1. History, which derives its materials from Memory; 2. Philosophy, which is the product of Reason; and 3. Poetry (comprehending under this title all the Fine Arts), which is the offspring of Imagination.[1] If we place Reason before Imagination, it is because this order appears to us conformable to the natural progress of our intellectual operations.[2] The Imagination is a creative faculty, and the mind,

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[1] The latitude given by D'Alembert to the meaning of the word *Poetry* is a real and very important improvement on Bacon, who restricts it to fictitious History or Fables. (*De Aug. Scient.* Lib. ii. cap. i.) D'Alembert, on the other hand, employs it in its natural signification, as synonymous with *invention* or *creation.* "La Peinture, la Sculpture, l'Architecture, la Poésie, la Musique, et leurs différentes divisions, composent la troisième distribution générale qui nait de l'Imagination, et dont les parties sont comprises sous le nom de Beaux-Arts. On peut les rapporter tous à la Poésie, en prenant ce mot dans sa signification naturelle, qui n'est autre chose qu'invention ou création."

[2] In placing Reason before Imagination, D'Alembert departs from the order in which these faculties are arranged by Bacon. "Si nous n'avons pas placé, comme lui, la Raison après l'Imagination, c'est que nous

before it attempts to create, begins by reasoning upon what it sees and knows. Nor is this all. In the faculty of Imagination, both Reason and Memory are, to a certain extent, combined,—the mind never imagining or creating objects but such as are analogous to those whereof it has had previous experience. Where this analogy is wanting, the combinations are extravagant and displeasing; and consequently, in that agreeable imitation of nature, at which the fine arts aim in common, invention is necessarily subjected to the control of rules which it is the business of the philosopher to investigate.

"In farther justification of this arrangement, it may be remarked, that Reason, in the course of its successive operations on the subjects of thought, by creating abstract and general ideas, remote from the perceptions of sense, leads to the exercise of Imagination as the last step of the process. Thus metaphysics and geometry are, of all the sciences belonging to Reason, those in which Imagination has the greatest share. I ask pardon for this observation from those men of taste, who, little aware of the near affinity of geometry to their own pursuits, and still less suspecting that the only intermediate step between them is formed by metaphysics, are disposed to employ their wit in depreciating its value. The truth is, that, to the geometer who invents, Imagination is not less essential than to the poet who creates. They operate, indeed, differently on their object, the former abstracting and analyzing, where the latter combines and adorns;—two processes of the mind, it must, at the same time, be confessed, which seem from experience to be so little congenial, that it may be doubted if the talents of a great geometer and of a great poet will ever be united in the same person. But whether these talents be, or be not mutually exclusive, certain it is, that they who possess the one, have no right to despise those who cultivate the other. Of all the great men of antiquity, Archimedes is perhaps he who is the best entitled to be placed by the side of Homer."

D'Alembert afterwards proceeds to observe, that of these three general branches of the Encyclopedical Tree, a natural and convenient subdivision is afforded by the metaphysical distribution of things into Material and Spiritual. "With these two classes of existences," he observes farther, "history and philosophy are equally conversant; but *as for the Imagination, her imitations are entirely confined to the material world;*—a circumstance," he adds, "which conspires with the other arguments above stated, in justifying Bacon for

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avons suivi, dans le système Encyclopédique, l'ordre metaphysique des operations de l'esprit, plutôt que l'ordre historique de ses progrès depuis la renaissance des lettres."—*(Disc. Prelim.)* How far the motive here assigned for the change is valid, the reader will be enabled to judge from the sequel of the above quotation.

assigning to her the *last* place in his enumeration of our intellectual faculties."[1] Upon this subdivision he enlarges at some length, and with considerable ingenuity; but on the present occasion it would be quite superfluous to follow him any farther, as more than enough has been already quoted to enable my readers to judge, whether the objections which I am now to state to the foregoing extracts be as sound and decisive as I apprehend them to be.

Of these objections a very obvious one is suggested by a consideration, of which D'Alembert himself has taken notice,—that the three faculties to which he refers the whole operations of the understanding are perpetually blended together in their actual exercise, insomuch that there is scarcely a branch of human knowledge which does not, in a greater or less degree, furnish employment to them all. It may be said, indeed, that some pursuits exercise and invigorate particular faculties *more* than others; that the study of History, for example, although it may occasionally require the aid both of Reason and of Imagination, yet chiefly furnishes occupation to the Memory; and that this is sufficient to justify the logical division of our mental powers as the ground-work of a corresponding Encyclopedical classification.[2] This, however, will be found more specious than solid. In what respects is the faculty of Memory more essentially necessary to the student of history than to the philosopher or to the poet; and, on the other hand, of what value, in the circle of the sciences, would be a collection of historical details, accumulated without discrimination, without a scrupulous examination of evidence, or without any attempt to compare and to generalize? For the cultivation of that species of history, in particular, which alone deserves a place in the Encyclopedical Tree, it may be justly affirmed, that the rarest and most comprehensive combination of all our mental gifts is indispensably requisite.

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[1] In this exclusive limitation of the province of Imagination to things Material and Sensible, D'Alembert has followed the definition given by Descartes in his second Meditation: "*Imaginari nihil aliud est quam rei corporeæ figuram seu imaginem contemplari;*"—a power of the mind, which (as I have elsewhere observed) appears to me to be most precisely expressed in our language by the word *Conception.* The province assigned to Imagination by D'Alembert is more extensive than this, for he ascribes to her also a creative and combining power; but still his definition agrees with that of Descartes, inasmuch as it excludes entirely from her dominion both the intellectual and the moral worlds.

[2] I allude here to the following apology for Bacon, suggested by a very learned and judicious writer:

"On a fait cependant à Bacon quelques reproches assez fondés. On a observé que sa classification des sciences repose sur une distinction qui n'est pas rigoureuse, puisque la mémoire, la raison, et l'imagination concourent nécessairement dans chaque art, comme dans chaque science. Mais on peut répondre, que l'un ou l'autre de ces trois facultés, quoique secondée par les deux autres, peut cependant jouer le rôle principal. En prenant la distinction de Bacon dans ce sens, sa classification reste exacte, et devient très utile."—(Degerando, *Hist. Comp.* Tome I. p. 298.)

Another, and a still more formidable objection to Bacon's classification, may be derived from the very imperfect and partial analysis of the mind which it assumes as its basis. Why were the powers of Abstraction and Generalization passed over in silence?—powers which, according as they are cultivated or neglected, constitute the most essential of all distinctions between the intellectual characters of individuals. A corresponding distinction, too, not less important, may be remarked among the objects of human study, according as our aim is to treasure up particular facts, or to establish general conclusions. Does not this distinction mark out, with greater precision, the limits which separate philosophy from mere historical narrative, than that which turns upon the different provinces of Reason and of Memory?

I shall only add one other criticism on this celebrated enumeration, and that is, its want of distinctness, in confounding together the Sciences and the Arts under the same general titles. Hence a variety of those capricious arrangements, which must immediately strike every reader who follows Bacon through his details; the reference, for instance, of the mechanical arts to the department of History; and consequently, according to his own analysis of the Mind, the ultimate reference of these arts to the faculty of Memory: while, at the same time, in his tripartite division of the whole field of human knowledge, the art of Poetry has one entire province allotted to itself.

These objections apply in common to Bacon and to D'Alembert. That which follows has a particular reference to a passage already cited from the latter, where, by some false refinements concerning the nature and functions of Imagination, he has rendered the classification of his predecessor incomparably more indistinct and illogical than it seemed to be before.

That all the creations, or new combinations of Imagination, imply the previous process of decomposition or analysis, is abundantly manifest; and, therefore, without departing from the common and popular use of language, it may undoubtedly be said, that the faculty of abstraction is not less essential to the Poet, than to the Geometer and the Metaphysician.[1] But this is not the doctrine of D'Alembert. On the contrary, he affirms, that

[1] This assertion must, however, be understood with some qualifications; for, although the Poet, as well as the Geometer and the Metaphysician, be perpetually called upon to decompose, by means of abstraction, the complicated objects of perception, it must not be concluded that the abstractions of all the three are exactly of the same kind. Those of the Poet, amount to nothing more than to a separation into parts of the realities presented to his senses; which separation is only a preliminary step to a subsequent recomposition into new and ideal forms of the things abstracted; whereas the abstractions of the Metaphysician and of the Geometer form the very objects of their respective sciences.

Metaphysics and Geometry are, of all the sciences connected with reason, those in which Imagination has the greatest share; an assertion which, it will not be disputed, has at first sight somewhat of the air of a paradox; and which, on closer examination, will, I apprehend, be found altogether inconsistent with fact. If indeed D'Alembert had, in this instance, used (as some writers have done) the word Imagination as synonymous with Invention, I should not have thought it worth while (at least so far as the geometer is concerned) to dispute his proposition. But that this was not the meaning annexed to it by the author, appears from a subsequent clause, where he tells us, that the most refined operations of reason, consisting in the creation of *generals* which do not fall under the cognizance of our senses, naturally lead to the exercise of imagination. His doctrine, therefore, goes to the identification of Imagination with Abstraction; two faculties so very different in the direction which they give to our thoughts, that (according to his own acknowledgement) the man who is habitually occupied in exerting the one, seldom fails to impair both his capacity and his relish for the exercise of the other.

This identification of two faculties, so strongly contrasted in their characteristical features, was least of all to be expected from a logician, who had previously limited the province of Imagination to the imitation of material objects; a limitation, it may be remarked in passing, which is neither sanctioned by common use, nor by just views of the philosophy of the Mind. Upon what ground can it be alleged, that Milton's portrait of Satan's intellectual and moral character was not the offspring of the same creative faculty which gave birth to his Garden of Eden? After such a definition, however, it is difficult to conceive, how so very acute a writer should have referred to Imagination the abstractions of the geometer and of the metaphysician; and still more, that he should have attempted to justify this reference, by observing, that these abstractions do not fall under the cognizance of the senses. My own opinion is, that, in the composition of the whole passage, he had a view to the unexpected parallel between Homer and Archimedes, with which he meant, at the close, to surprise his readers.

If the foregoing strictures be well-founded, it seems to follow, not only that the attempt of Bacon and of D'Alembert to classify the sciences and arts according to a logical division of our faculties, is altogether unsatisfactory; but that every future attempt of the same kind may be expected to be liable to similar objections. In studying, indeed, the Theory of the Mind, it is necessary to push our analysis as far as the nature of the subject admits of; and, wherever the thing is possible, to examine its constituent principles separately and apart from each other: but this consideration itself, when combined with what was before stated on the endless variety of forms in which they may be blended together in our various intel-

lectual pursuits, is sufficient to shew how ill adapted such an analysis must for ever remain to serve as the basis of an Encyclopedical distribution.[1]

The circumstance to which this part of Bacon's philosophy is chiefly indebted for its popularity, is the specious simplicity and comprehensiveness of the distribution itself;—not the soundness of the logical views by which it was suggested. That all our intellectual pursuits may be referred to one or other of these three heads, History, Philosophy, and Poetry, may undoubtedly be said with considerable plausibility; the word History being understood to comprehend all our knowledge of particular facts and particular events; the word Philosophy, all the general conclusions or laws inferred from these particulars by induction; and the word Poetry, all the arts addressed to the imagination. Not that the enumeration, even with the help of this comment, can be considered as complete, for (to pass over entirely the other objections already stated) under which of these three heads shall we arrange the various branches of pure mathematics?

Are we therefore to conclude, that the magnificent design, conceived by Bacon, of enumerating, defining, and classifying the multifarious objects of human knowledge; (a design, on the successful accomplishment of which he himself believed that the advancement of the sciences essentially depended)—Are we to conclude, that this design was nothing more than the abortive offspring of a warm imagination, unsusceptible of any useful application to enlighten the mind, or to accelerate its progress? My own idea is widely different. The design was, in every respect, worthy of the sublime genius by which it was formed. Nor does it follow, because the execution was imperfect, that the attempt has been attended with no advantage. At the period when Bacon wrote, it was of much more consequence to exhibit to the learned a comprehensive sketch, than an accurate survey of the intellectual world;—such a sketch as, by pointing out to those whose views had been hitherto confined within the limits of particular regions, the relative positions and bearings of their respective districts, as parts of one great whole, might invite them all, for the common benefit, to a reciprocal exchange of their local riches. The societies or academies which, soon after,

[1] In justice to the authors of the Encyclopedical Tree prefixed to the French Dictionary, it ought to be observed, that it is spoken of by D'Alembert, in his Preliminary Discourse, with the utmost modesty and diffidence; and that he has expressed, not only his own conviction, but that of his colleague, of the impossibility of executing such a task in a manner likely to satisfy the public. "Nous sommes trop convaincus de l'arbitraire qui régnera toujours dans une pareille division, pour croire que notre systême soit l'unique ou le meilleure; il nous suffira que notre travail ne soit pas entièrement desapprouvé par les bons esprits." And, some pages afterwards, "Si le public éclairé donne son approbation à ces changemens, elle sera la recompense de notre docilité; et s'il ne les approuve pas, nous n'en serons que plus convaincus de l'impossibilité de former un Arbre Encyclopédique qui soit au gré de tout le monde."

sprung up in different countries of Europe, for the avowed purpose of contributing to the general mass of information, by the collection of insulated facts, conjectures, and queries, afford sufficient proof, that the anticipations of Bacon were not, in this instance, altogether chimerical.

In examining the details of Bacon's survey, it is impossible not to be struck (more especially when we reflect on the state of learning two hundred years ago) with the minuteness of his information, as well as with the extent of his views; or to forbear admiring his sagacity in pointing out, to future adventurers, the unknown tracks still left to be explored by human curiosity. If his classifications be sometimes artificial and arbitrary, they have at least the merit of including, under one head or another, every particular of importance; and of exhibiting these particulars with a degree of method and of apparent connection, which, if it does not always satisfy the judgment, never fails to interest the fancy, and to lay hold of the memory. Nor must it be forgotten, to the glory of his genius, that what he failed to accomplish remains to this day a desideratum in science,—that the intellectual chart delineated by him is, with all its imperfections, the only one of which modern philosophy has yet to boast;—and that the united talents of D'Alembert and of Diderot, aided by all the lights of the eighteenth century, have been able to add but little to what Bacon performed.

After the foregoing observations, it will not be expected that an attempt is to be made, in the following Essay, to solve a problem which has so recently baffled the powers of these eminent writers; and which will probably long continue to exercise the ingenuity of our successors. How much remains to be previously done for the improvement of that part of Logic, whose province it is to fix the limits by which contiguous departments of study are defined and separated! And how many unsuspected affinities may be reasonably presumed to exist among sciences, which, to our circumscribed views, appear at present the most alien from each other! The abstract geometry of Appollonius and Archimedes was found, after an interval of two thousand years, to furnish a torch to the physical inquiries of Newton; while, in the further progress of knowledge, the Etymology of Languages has been happily employed to fill up the chasms of Ancient History; and the conclusions of Comparative Anatomy, to illustrate the Theory of the Earth. For my own part, even if the task were executed with the most complete success, I should be strongly inclined to think, that its appropriate place in an Encyclopædia would be as a branch of the article on Logic;—certainly *not* as an *exordium* to the Preliminary Discourse; the enlarged and refined views which it necessarily presupposes being peculiarly unsuitable to that part of the work which may be expected, in the first instance, to attract the curiosity of every reader. As, upon this point,

however, there may be some diversity of opinion, I have prevailed on the Editor to add to these introductory Essays a translation of D'Alembert's Discourse, and of Diderot's Prospectus. No English version of either has, as far as I know, been hitherto published; and the result of their joint ingenuity, exerted on Bacon's ground-work, must for ever fix no inconsiderable era in the history of learning.

Before concluding this preface, I shall subjoin a few slight strictures on a very concise and comprehensive division of the objects of Human Knowledge, proposed by Mr Locke, as the basis of a new classification of the sciences. Although I do not know that any attempt has ever been made to follow out in detail the general idea, yet the repeated approbation which has been lately bestowed on a division essentially the same, by several writers of the highest rank, renders it in some measure necessary, on the present occasion, to consider how far it is founded on just principles; more especially as it is completely at variance, not only with the language and arrangement adopted in these preliminary essays, but with the whole of that plan on which the original projectors, as well as the continuators, of the *Encyclopædia Britannica*, appear to have proceeded. These strictures will, at the same time, afford an additional proof of the difficulty, or rather of the impossibility, in the actual state of logical science, of solving this great problem, in a manner calculated to unite the general suffrages of philosophers.

" All that can fall," says Mr Locke, " within the compass of Human Understanding being either, first, The nature of things as they are in themselves, their relations, and their manner of operation; or, secondly, That which man himself ought to do, as a rational and voluntary agent, for the attainment of any end, especially happiness; or, thirdly, The ways and means whereby the knowledge of both the one and the other of these is attained and communicated: I think science may be divided properly into these three sorts:

" 1. Φυσικὴ, or Natural Philosophy. The end of this is bare speculative truth; and whatsoever can afford the mind of man any such falls under this branch, whether it be God himself, angels, spirits, bodies, or any of their affections, as number and figure, &c.

" 2. Πρακτικὴ, The skill of right applying our own powers and actions for the attainment of things good and useful. The most considerable under this head is *Ethics*, which is the seeking out those rules and measures of human actions which lead to happiness, and the means to practise them. The end of this is not bare speculation, but right, and a conduct suitable to it. [1]

[1] From this definition it appears, that, as Locke included under the title of *Physics*, not only *Natural Philosophy*, properly so called, but *Natural Theology*, and the *Philosophy of the Human Mind*, so he meant to refer to the head of *Practics*, not only *Ethics*, but all the various *Arts* of life, both mechanical and liberal.

"3. Σημειωτικὴ, or *the doctrine of signs*, the most usual whereof being words, it is aptly enough termed also Λογικὴ, *Logic*. The business of this is to consider the nature of signs the mind makes use of for the understanding of things, or conveying its knowledge to others.

"This seems to me," continues Mr Locke, "*the first and most general, as well as natural*, division of the objects of our understanding; for a man can employ his thoughts about nothing but either the contemplation of *things* themselves, for the discovery of truth, or about the things in his own power, which are his own *actions*, for the attainment of his own ends; or the *signs* the mind makes use of, both in one and the other, and the right ordering of them for its clearer information. All which three, viz. things as they are in themselves knowable; actions as they depend on us, in order to happiness; and the right use of *signs*, in order to knowledge; being *toto cœlo* different, they seemed to me to be the three great provinces of the intellectual world, wholly separate and distinct one from another."[1]

From the manner in which Mr Locke expresses himself in the above quotation, he appears evidently to have considered the division proposed in it as an original idea of his own; and yet the truth is, that it coincides exactly with what was generally adopted by the philosophers of ancient Greece. "The ancient Greek Philosophy," says Mr Smith, "was divided into three great branches, Physics, or Natural Philosophy; Ethics, or Moral Philosophy; and Logic. *This general division*," he adds, "*seems perfectly agreeable to the nature of things*." Mr Smith afterwards observes, in strict conformity to Locke's definitions, (of which, however, he seems to have had no recollection when he wrote this passage), "That, as the human mind and the Deity, in whatever their essence may be supposed to consist, are parts of the great system of the universe, and parts, too, productive of the most important effects, whatever was taught in the ancient schools of Greece concerning their nature, made a part of the system of physics."[2]

Dr Campbell, in his *Philosophy of Rhetoric*, has borrowed from the Grecian schools the same very extensive use of the words *physics* and *physiology*, which he employs as synonymous terms; comprehending under this title "not merely Natural History, Astronomy, Geography, Mechanics, Optics, Hydrostatics, Meteorology, Medicine, Chemistry, but also Natural Theology and Psychology, which," he observes, "have been, in his opinion, most unnaturally disjoined from Physiology by philosophers." "Spirit," he adds, "which here com-

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[1] See the concluding chapter of the *Essay on Human Understanding*, entitled, "Of the Division of the Sciences."

[2] *Wealth of Nations*, Book v. chap. i.

prises only the Supreme Being and the human soul, is surely as much included under the notion of natural object as body is; and is knowable to the philosopher purely in the same way, by observation and experience."[1]

A similar train of thinking led the late celebrated M. Turgot to comprehend under the name of Physics, not only Natural Philosophy (as that phrase is understood by the Newtonians), but Metaphysics, Logic, and even History.[2]

Notwithstanding all this weight of authority, it is difficult to reconcile one's self to an arrangement which, while it classes with Astronomy, with Mechanics, with Optics, and with Hydrostatics, the strikingly contrasted studies of Natural Theology and of the Philosophy of the Human Mind, disunites from the two last the far more congenial sciences of Ethics and of Logic. The human mind, it is true, as well as the material world which surrounds it, forms a part of the great system of the Universe; but is it possible to conceive two parts of the same whole more completely dissimilar, or rather more diametrically opposite, in all their characteristical attributes? Is not the one the appropriate field and province of *observation*,—a power habitually awake to all the perceptions and impressions of the bodily organs? and does not the other fall exclusively under the cognizance of *reflection*,—an operation which inverts all the ordinary habits of the understanding,—abstracting the thoughts from every sensible object, and even striving to abstract them from every sensible image? What abuse of language can be greater, than to apply a common name to departments of knowledge which invite the curiosity in directions precisely contrary, and which tend to form intellectual talents, which, if not altogether incompatible, are certainly not often found united in the same individual? The word *Physics*, in particular, which, in our language, long and constant use has restricted to the phenomena of Matter, cannot fail to strike every ear as *anomalously*, and therefore *illogically*, applied, when extended to those of Thought and of Consciousness.

Nor let it be imagined that these observations assume any particular theory about the nature or essence of Mind. Whether we adopt, on this point, the language of the Material-

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[1] *Philosophy of Rhetoric*, Book i. chap. v. Part iii. § 1.

[2] "Sous le nom de sciences physiques je comprends la logique, qui est la connoissance des operations de notre esprit et de la generation de nos idées, la metaphysique, qui s'occupe de la nature et de l'origine des êtres, et enfin la physique, proprement dite, qui observe l'action mutuel des corps les uns sur les autres, et les causes et l'enchainement des phenomênes sensibles. *On pourroit y ajouter l'histoire.*"—(*Oeuvres de Turgot*, Tome II. pp. 284, 285.)

In the year 1795, a quarto volume was published at Bath, entitled *Intellectual Physics*. It consists entirely of speculations concerning the human mind, and is by no means destitute of merit. The publication was anonymous; but I have reason to believe that the author was the late well-known Governor Pownall.

ists, or that of their opponents, it is a proposition equally certain and equally indisputable, that the phenomena of Mind and those of Matter, as far as they come under the cognizance of our faculties, appear to be more completely heterogeneous than any other classes of facts within the circle of our knowledge; and that the sources of our information concerning them are in every respect so radically different, that nothing is more carefully to be avoided, in the study of either, than an attempt to assimilate them, by means of analogical or metaphorical terms, applied to both in common. In those inquiries, above all, where we have occasion to consider Matter and Mind as conspiring to produce the same joint effects (in the constitution, for example, of our own compounded frame), it becomes more peculiarly necessary to keep constantly in view the distinct province of each, and to remember, that the business of philosophy is not to resolve the phenomena of the one into those of the other, but merely to ascertain the general laws which regulate their mutual connection. *Matter* and *Mind*, therefore, it should seem, are the two most general heads which ought to form the ground-work of an Encyclopedical classification of the sciences and arts. No branch of human knowledge, no work of human skill, can be mentioned, which does not obviously fall under the former head or the latter.

Agreeably to this twofold classification of the sciences and arts, it is proposed, in the following introductory Essays, to exhibit a rapid sketch of the progress made since the revival of letters: *First*, in those branches of knowledge which relate to Mind; and, *secondly*, in those which relate to Matter. D'Alembert, in his Preliminary Discourse, has boldly attempted to embrace both subjects in one magnificent design; and never, certainly, was there a single mind more equal to such an undertaking. The historical outline which he has there traced forms by far the most valuable portion of that performance, and will for ever remain a proud monument to the depth, to the comprehensiveness, and to the singular versatility of his genius. In the present state of science, however, it has been apprehended, that, by dividing so great a work among different hands, something might perhaps be gained, if not in point of reputation to the authors, at least in point of instruction to their readers. This division of labour was, indeed, in some measure, rendered necessary (independently of all other considerations), by the important accessions which mathematics and physics have received since D'Alembert's time;—by the innumerable improvements which the spirit of mercantile speculation, and the rivalship of commercial nations, have introduced into the mechanical arts;—and, above all, by the rapid succession of chemical discoveries which commences with the researches of Black and of Lavoisier. The part of this task which has fallen to my share is certainly, upon the whole, the least splendid in the results which it has to record; but I am not without hopes, that this disadvantage may be partly

compensated by its closer connection with (what ought to be the ultimate end of all our pursuits) the intellectual and moral improvement of the species.

I am, at the same time, well aware that, in proportion as this last consideration increases the importance, it adds to the difficulty of my undertaking. It is chiefly in judging of questions "coming home to their business and bosoms," that casual associations lead mankind astray; and of such associations how incalculable is the number arising from false systems of religion, oppressive forms of government, and absurd plans of education! The consequence is, that while the physical and mathematical discoveries of former ages present themselves to the hand of the historian, like masses of pure and native gold, the truths which we are here in quest of may be compared to *iron*, which, although at once the most necessary and the most widely diffused of all the metals, commonly requires a discriminating eye to detect its existence, and a tedious, as well as nice process, to extract it from the ore.

To the same circumstance it is owing, that improvements in Moral and in Political Science do not strike the imagination with nearly so great force as the discoveries of the Mathematician or of the Chemist. When an inveterate prejudice is destroyed by extirpating the casual associations on which it was grafted, how powerful is the new impulse given to the intellectual faculties of man! Yet how slow and silent the process by which the effect is accomplished! Were it not, indeed, for a certain class of learned authors, who, from time to time, heave the log into the deep, we should hardly believe that the reason of the species is progressive. In this respect, the religious and academical establishments in some parts of Europe are not without their use to the historian of the Human Mind. Immovably moored to the same station by the strength of their cables, and the weight of their anchors, they enable him to measure the rapidity of the current by which the rest of the world are borne along.

*This*, too, is remarkable in the history of our prejudices; that, as soon as the film falls from the intellectual eye, we are apt to lose all recollection of our former blindness. Like the fantastic and giant shapes which, in a thick fog, the imagination lends to a block of stone, or to the stump of a tree, they produce, while the illusion lasts, the same effect with truths and realities; but the moment the eye has caught the exact form and dimensions of its object, the spell is broken for ever; nor can any effort of thought again conjure up the spectres which have vanished.

As to the subdivisions of which the sciences of Matter and of Mind are susceptible, I have already said, that this is not the proper place for entering into any discussion concerning them. The passages above quoted from D'Alembert, from Locke, and from Smith, are sufficient to shew how little probability there is, in the actual state of Logical Science,

of uniting the opinions of the learned, in favour of any one scheme of partition. To prefix, therefore, such a scheme to a work which is professedly to be carried on by a set of unconnected writers, would be equally presumptuous and useless; and, on the most favourable supposition, could tend only to fetter, by means of dubious definitions, the subsequent freedom of thought and of expression. The example of the French *Encyclopédie* cannot be here justly alleged as a precedent. The preliminary pages by which it is introduced were written by the two persons who projected the whole plan, and who considered themselves as responsible, not only for their own admirable articles, but for the general conduct of the execution; whereas, on the present occasion, a porch was to be adapted to an irregular edifice, reared, at different periods, by different architects. It seemed, accordingly, most advisable to avoid, as much as possible, in these introductory Essays, all innovations in language, and, in describing the different arts and sciences, to follow scrupulously the prevailing and most intelligible phraseology. The task of defining them, with a greater degree of precision, properly devolves upon those to whose province it belongs, in the progress of the work, to unfold in detail their elementary principles.

The sciences to which I mean to confine my observations are Metaphysics, Ethics, and Political Philosophy; understanding, by Metaphysics, not the Ontology and Pneumatology of the schools, but the inductive Philosophy of the Human Mind; and limiting the phrase Political Philosophy almost exclusively to the modern science of Political Economy; or (to express myself in terms at once more comprehensive and more precise) to that branch of the theory of legislation which, according to Bacon's definition, aims to ascertain those "Leges legum, ex quibus informatio peti potest quid in singulis legibus bene aut perperam positum aut constitutum sit." The close affinity between these three departments of knowledge, and the easy transitions by which the curiosity is invited from the study of any one of them to that of the other two, will sufficiently appear from the following Historical Review.

# DISSERTATION FIRST.

## PART I.

In the following Historical and Critical Sketches, it has been judged proper by the different writers, to confine their views entirely to the period which has elapsed since the *revival of letters*. To have extended their retrospects to the ancient world would have crowded too great a multiplicity of objects into the limited canvas on which they had to work. For my own part, I might perhaps, with still greater propriety, have confined myself exclusively to the two last centuries; as the Sciences of which I am to treat present but little matter for useful remark, prior to the time of Lord Bacon. I shall make no apology, however, for devoting, in the first place, a few pages to some observations of a more general nature; and to some scanty gleanings of literary detail, bearing more or less directly on my principal design.

On this occasion, as well as in the sequel of my Discourse, I shall avoid, as far as is consistent with distinctness and perspicuity, the minuteness of the mere bibliographer; and, instead of attempting to amuse my readers with a series of critical epigrams, or to dazzle them with a rapid succession of evanescent portraits, shall study to fix their attention on those great *lights of the world* by whom the torch of science has been successively seized and transmitted.[1] It is, in fact, such leading characters alone which furnish matter

[1] I have ventured here to combine a scriptural expression with an allusion of Plato's to a Grecian game; an allusion which, in his writings, is finely and pathetically applied to the rapid succession of generations,

for philosophical history. To enumerate the names and the labours of obscure or even secondary authors (whatever amusement it might afford to men of curious erudition), would contribute but little to illustrate the origin and filiation of consecutive systems, or the gradual developement and progress of the human mind.

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## CHAPTER I.

### FROM THE REVIVAL OF LETTERS TO THE PUBLICATION OF BACON'S PHILOSOPHICAL WORKS.

THE long interval, commonly known by the name of the *middle ages*, which immediately preceded the revival of letters in the western part of Europe, forms the most melancholy blank which occurs, from the first dawn of recorded civilization, in the intellectual and moral history of the human race. In one point of view alone, the recollection of it is not altogether unpleasing, in as much as, by the proof it exhibits of the inseparable connection between ignorance and prejudice on the one hand, and vice, misery, and slavery, on the other, it affords, in conjunction with other causes, which will afterwards fall under our review, some security against any future recurrence of a similar calamity.

It would furnish a very interesting and instructive subject of speculation, to record and to illustrate (with the spirit, however, rather of a philosopher than of an antiquary), the various abortive efforts, which, during this protracted and seemingly hopeless period of a thousand years, were made by enlightened individuals, to impart to their contemporaries the fruits of their own acquirements. For in no one age from its commencement to its close, does *the continuity of knowledge* (if I may borrow an expression of Mr Harris), seem to have been entirely interrupted: "There was always a faint twilight, like that auspicious gleam which, in a summer's night, fills up the interval between the setting and the rising sun."[1] On the present occasion, I shall content myself with remarking the important effects produced by the numerous monastic establishments all over the Christian

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through which the continuity of human life is maintained from age to age; and which are perpetually transferring from hand to hand the concerns and duties of this fleeting scene. Γεννωντες ϗ εκτρεφοντες παιδας, καθαπερ λαμπαδα τον βιον παραδιδοντες αλλοις εξ αλλων. (Plato, *Leg.* lib. vi.)

Et quasi cursores vitaï lampada tradunt.——*Lucret.*

[1] *Philological Inquiries*, Part III. chap. i.

world, in preserving, amidst the general wreck, the inestimable remains of Greek and Roman refinement; and in keeping alive, during so many centuries, those scattered sparks of truth and of science, which were afterwards to kindle into so bright a flame. I mention this particularly, because, in our zeal against the vices and corruptions of the Romish church, we are too apt to forget, how deeply we are indebted to its superstitious and apparently useless foundations, for the most precious advantages that we now enjoy.

The study of the Roman Law, which, from a variety of causes, natural as well as accidental, became, in the course of the twelfth century, an object of general pursuit, shot a strong and auspicious ray of intellectual light across the surrounding darkness. No study could then have been presented to the curiosity of men, more happily adapted to improve their taste, to enlarge their views, or to invigorate their reasoning powers; and although, in the first instance, prosecuted merely as the object of a weak and undistinguishing idolatry, it nevertheless conducted the student to the very confines of ethical as well as of political speculation; and served, in the meantime, as a substitute of no inconsiderable value for both these sciences. Accordingly we find that, while in its *immediate* effects it powerfully contributed, wherever it struck its roots, by ameliorating and systematizing the administration of justice, to accelerate the progress of order and of civilization, it afterwards furnished, in the farther career of human advancement, the parent stock on which were grafted the first rudiments of pure ethics and of liberal politics taught in modern times. I need scarcely add, that I allude to the systems of *natural jurisprudence* compiled by Grotius and his successors; systems which, for a hundred and fifty years, engrossed all the learned industry of the most enlightened part of Europe; and which, however unpromising in their first aspect, were destined, in the last result, to prepare the way for that never to be forgotten change in the literary taste of the eighteenth century, "which has everywhere turned the spirit of philosophical inquiry from frivolous or abstruse speculations, to the business and affairs of men." [1]

The revival of letters may be considered as coëval with the fall of the Eastern empire, towards the close of the fifteenth century. In consequence of this event, a number of learned Greeks took refuge in Italy, where the taste for literature already introduced by Dante, Petrarch, and Boccacio, together with the liberal patronage of the illustrious House of Medicis, secured them a welcome reception. A knowledge of the Greek tongue

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[1] Dr Robertson, from whom I quote these words, has mentioned this change as the glory of the *present age*, meaning I presume, the period which has elapsed since the time of Montesquieu. By what steps the philosophy to which he alludes took its rise from the systems of jurisprudence previously in fashion, will appear in the sequel of this Discourse.

soon became fashionable; and the learned, encouraged by the rapid diffusion which the art of printing now gave to their labours, vied with each other in rendering the Greek authors accessible, by means of Latin translations, to a still wider circle of readers.

For a long time, indeed, after the era just mentioned, the progress of useful knowledge was extremely slow. The passion for logical disputation was succeeded by an unbounded admiration for the wisdom of antiquity; and in proportion as the pedantry of the schools disappeared in the universities, that of erudition and philology occupied its place.

Meanwhile, an important advantage was gained in the immense stock of materials which the ancient authors supplied to the reflections of speculative men; and which, although frequently accumulated with little discrimination or profit, were much more favourable to the developement of taste and of genius than the unsubstantial subtleties of ontology or of dialectics. By such studies were formed Erasmus, [1] Ludovicus Vives, [2] Sir Thomas More, [3] and many other accomplished scholars of a similar character, who, if they

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[1] The writings of Erasmus probably contributed still more than those of Luther himself to the progress of the Reformation among men of education and taste; but, without the co-operation of bolder and more decided characters than his, little would to this day have been effected in Europe among the lower orders. "Erasmus imagined," as is observed by his biographer "that at length, by training up youth in learning and useful knowledge, those religious improvements would gradually be brought about, which the Princes, the Prelates, and the Divines of his days could not be persuaded to admit or to tolerate." (Jortin, p. 279.) In yielding, however, to this pleasing expectation, Erasmus must have flattered himself with the hope, not only of a perfect freedom of literary discussion, but of such reforms in the prevailing modes of instruction, as would give complete scope to the energies of the human mind;—for, where books and teachers are subjected to the censorship of those who are hostile to the dissemination of truth, they become the most powerful of all auxiliaries to the authority of established errors.

It was long a proverbial saying among the ecclesiastics of the Romish church, that "Erasmus laid the egg, and Luther hatched it;" and there is more truth in the remark, than in most of their sarcasms on the same subject.

[2] Ludovicus Vives was a learned Spaniard, intimately connected both with Erasmus and More; with the former of whom he lived for some time at Louvain; "where they both promoted literature as much as they could, though not without great opposition from some of the divines." Jortin, p. 255.

"He was invited into England by Wolsey, in 1523; and coming to Oxford, he read the Cardinal's lecture of *Humanity*, and also lectures of Civil Law, which Henry VIII. and his Queen, Catharine, did him the honour of attending." (Ibid. p. 207). He died at Bruges in 1554.

In point of good sense and acuteness, wherever he treats of philosophical questions, he yields to none of his contemporaries; and in some of his anticipations of the future progress of science, he discovers a mind more comprehensive and sagacious than any of them. Erasmus appears, from a letter of his to Budæus (dated in 1521), to have foreseen the brilliant career which Vives, then a very young man, was about to run. "Vives in stadio literario, non minus feliciter quam gnaviter decertat, et si satis ingenium hominis novi, non conquiescet, donec omnes a tergo reliquerit."—For this letter (the whole of which is peculiarly interesting, as it contains a character of Sir Thomas More, and an account of the extraordinary accomplishments of his daughters), See Jortin's *Life of Erasmus*, Vol. II. p. 366, *et seq.*

[3] See Note A.

do not rank in the same line with the daring reformers by whom the errors of the Catholic church were openly assailed, certainly exhibit a very striking contrast to the barbarous and unenlightened writers of the preceding age.

The Protestant Reformation, which followed immediately after, was itself one of the natural consequences of the revival of letters, and of the invention of printing. But although, in one point of view, only an *effect*, it is not, on the present occasion, less entitled to notice than the *causes* by which it was produced.

The renunciation, in a great part of Europe, of theological opinions so long consecrated by time, and the adoption of a creed more pure in its principles and more liberal in its spirit, could not fail to encourage, on all other subjects, a congenial freedom of inquiry. These circumstances operated still more directly and powerfully, by their influence in undermining the authority of Aristotle ; an authority which for many years was scarcely inferior in the schools to that of the Scriptures ; and which, in some Universities, was supported by statutes, requiring the teachers to promise upon oath, that, in their public lectures, they would follow no other guide.

Luther,[1] who was perfectly aware of the corruptions which the Romish church had contrived to connect with their veneration for the Stagirite,[2] not only threw off the yoke himself, but, in various parts of his writings, speaks of Aristotle with most unbecoming asperity and contempt.[3] In one very remarkable passage, he asserts, that the study of Aristotle was wholly useless, not only in Theology, but in Natural Philosophy. " What does it contribute," he asks, " to the knowledge of things, to trifle and cavil in language conceived and prescribed by Aristotle, concerning matter, form, motion, and time ?"[4] The same

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[1] Born 1483, died 1546.

[2] In one of his letters he writes thus : " Ego simpliciter credo, quod impossibile sit ecclesiam reformari, nisi funditus canones, decretales, scholastica theologia, philosophia, logica, ut nunc habentur, eradicentur, et alia instituantur." Bruckeri *Hist. Crit. Phil.* Tom. IV. p. 95.

[3] For a specimen of Luther's scurrility against Aristotle, see Bayle, Art. *Luther*, Note HH.

In Luther's *Colloquia Mensalia* we are told, that " he abhorred the Schoolmen, and called them sophistical locusts, caterpillars, frogs, and lice." From the same work we learn, that " he hated Aristotle, but highly esteemed Cicero, as a wise and good man." See Jortin's *Life of Erasmus*, p. 121.

[4] " Nihil adjumenti ex ipso haberi posse non solum ad theologiam seu sacras literas, verum etiam ad ipsam naturalem philosophiam. Quid enim juvet ad rerum cognitionem, si de materia, forma, motu, tempore, nugari et cavillari queas verbis ab Aristotele conceptis et præscriptis ?" Bruck. *Hist. Phil.* Tom. IV. p. 101.

The following passage to the same purpose is quoted by Bayle : " Non mihi persuadebitis, philosophiam esse garrulitatem illam de materia, motu, infinito, loco, vacuo, tempore, quæ ferè in Aristotele sola discimus, talia quæ nec intellectum, nec affectum, nec communes hominum mores quidquam juvent ; tantum contentionibus serendis, seminandisque idonea." Bayle, Art. *Luther*, Note HH.

I borrow from Bayle another short extract from Luther : " Nihil ita ardet animus, quàm histrionem illum, (Aristotelem,) qui tam verè Græca larva ecclesiam lusit, multis revelare, ignominiamque ejus cunctis

freedom of thought on topics not strictly theological, formed a prominent feature in the character of Calvin. A curious instance of it occurs in one of his letters, where he discusses an ethical question of no small moment in the science of political economy;—"How far it is consistent with morality to accept of interest for a pecuniary loan?" On this question, which, even in Protestant countries, continued, till a very recent period, to divide the opinions both of divines and lawyers, Calvin treats the authority of Aristotle and that of the church with equal disregard. To the former, he opposes a close and logical argument, not unworthy of Mr Bentham. To the latter he replies, by shewing, that the Mosaic law on this point was not a moral but a municipal prohibition; a prohibition not to be judged of from any particular text of Scripture, but upon the principles of natural equity.[1] The example of these two Fathers of the Reformation, would probably have been followed by consequences still greater and more immediate, if Melanchthon had not unfortunately given the sanction of his name to the doctrines of the Peripatetic school:[2] but still, among the Reformers in general, the credit of these doctrines gradually declined, and a spirit of research and of improvement prevailed.

The invention of printing, which took place very nearly at the same time with the fall of the Eastern Empire, besides adding greatly to the efficacy of the causes above-mentioned, must have been attended with very important effects of its own, on the progress of the human mind. For us who have been accustomed, from our infancy, to the use of books, it is not easy to form an adequate idea of the disadvantages which those laboured under, who had to acquire the whole of their knowledge through the medium of universities and schools;—blindly devoted as the generality of students must then have been to the peculiar opinions of the teacher, who first unfolded to their curiosity the treasures of literature and the wonders of science. Thus error was perpetuated; and, instead of yielding to time, acquired additional influence in each successive generation.[3] In

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ostendere, si otium esset. Habeo in manus commentariolos in 1. Physicorum, quibus fabulam Aristæi denuò agere statui in meum istum Protea (Aristotelem). Pars crucis meæ vel maxima est, quod videre cogor fratrum optima ingenia, bonis studiis nata, in istis cœnis vitam agere, et operam perdere." Ibid.

That Luther was deeply skilled in the scholastic philosophy we learn from very high authority, that of Melanchthon; who tells us farther, that he was a strenuous partizan of the sect of *Nominalists*, or, as they were then generally called, *Terminists*. Bruck. Tom. IV. pp. 93, 94, *et seq.*

[1] See Note B.

[2] "Et Melanchthoni quidem præcipue debetur conservatio philosophiæ Aristotelicæ in academiis protestantium Scripsit is compendia plerarumque disciplinarum philosophiæ Aristotelicæ, quæ in Academiis diu regnarunt." Heineccii, *Elem. Hist. Phil.* § ciii. See also *Bayle's Dictionary*, Art. *Melanchthon.*

[3] It was in consequence of this mode of conducting education by means of oral instruction alone, that the different sects of philosophy arose in ancient Greece; and it seems to have been with a view of counter-

modern times, this influence of names is, comparatively speaking, at an end. The object of a public teacher is no longer to inculcate a particular system of dogmas, but to prepare his pupils for exercising their own judgments; to exhibit to them an outline of the different sciences, and to suggest subjects for their future examination. The few attempts to establish schools and to found sects, have all (after perhaps a temporary success) proved abortive. Their effect, too, during their short continuance, has been perfectly the reverse of that of the schools of antiquity; for whereas these were instrumental, on many occasions, in establishing and diffusing error in the world, the founders of our modern sects, by mixing up important truths with their own peculiar tenets, and by disguising them under the garb of a technical phraseology, have fostered such prejudices against themselves, as have blinded the public mind to all the lights they were able to communicate. Of this remark a melancholy illustration occurs (as M. Turgot long ago predicted) in the case of the French Economists; and many examples of a similar import might be produced from the history of science in our country; more particularly from the history of the various medical and metaphysical schools which successively rose and fell during the last century.

With the circumstances already suggested, as conspiring to accelerate the progress of knowledge, another has co-operated very extensively and powerfully; the rise of the lower orders in the different countries of Europe,—in consequence partly of the enlargement of commerce, and partly of the efforts of the Sovereigns to reduce the overgrown power of the feudal aristocracy.

Without this emancipation of the lower orders, and the gradual diffusion of wealth by which it was accompanied, the advantages derived from the invention of printing would have been extremely limited. A certain degree of ease and independence is essentially requisite to inspire men with the desire of knowledge, and to afford the leisure necessary

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acting the obvious inconveniences resulting from them, that Socrates introduced his peculiar method of questioning, with an air of sceptical diffidence, those whom he was anxious to instruct; so as to allow them, in forming their conclusions, the complete and unbiassed exercise of their own reason. Such, at least, is the apology offered for the apparent indecision of the Academic school, by one of its wisest, as well as most eloquent adherents. "As for other sects," says Cicero, "who are bound in fetters, before they are able to form any judgment of what is right or true, and who have been led to yield themselves up, in their tender years, to the guidance of some friend, or to the captivating eloquence of the teacher whom they have first heard, they assume to themselves the right of pronouncing upon questions of which they are completely ignorant; adhering to whatever creed the wind of doctrine may have driven them, as if it were the only rock on which their safety depended." Cic. *Lucullus*, 3.

for acquiring it; and it is only by the encouragement which such a state of society presents to industry and ambition, that the selfish passions of the multitude can be interested in the intellectual improvement of their children. It is only, too, in such a state of society, that education and books are likely to increase the sum of human happiness; for while these advantages are confined to one privileged description of individuals, they but furnish them with an additional engine for debasing and misleading the minds of their inferiors. To all which it may be added, that it is chiefly by the shock and collision of different and opposite prejudices, that truths are gradually cleared from that admixture of error which they have so strong a tendency to acquire, wherever the course of public opinion is forcibly constrained and guided within certain artificial channels, marked out by the narrow views of human policy. The diffusion of knowledge, therefore, occasioned by the rise of the lower orders, would necessarily contribute to the improvement of useful science, not merely in proportion to the arithmetical number of cultivated minds now combined in the pursuit of truth, but in a proportion tending to accelerate that important effect with a far greater rapidity.

Nor ought we here to overlook the influence of the foregoing causes, in encouraging among authors the practice of addressing the multitude in their own vernacular tongues. The zeal of the Reformers first gave birth to this invaluable innovation; and imposed on their adversaries the necessity of employing, in their own defence, the same weapons.[1] From that moment the prejudice began to vanish which had so long confounded knowledge with erudition; and a revolution commenced in the republic of letters, analogous to what the invention of gunpowder produced in the art of war. "All the splendid distinctions of mankind," as the Champion and Flower of Chivalry indignantly exclaimed, "were thereby thrown down; and the naked shepherd levelled with the knight clad in steel."

To all these considerations may be added the gradual effects of time and experience in correcting the errors and prejudices which had misled philosophers during so long a succession of ages. To this cause, chiefly, must be ascribed the ardour with which we

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1 "The sacred books were, in almost all the kingdoms and states of Europe, translated into the language of each respective people, particularly in Germany, Italy, France, and Britain." (Mosheim's *Eccles. Hist.* Vol. III. p. 265.) The effect of this single circumstance in multiplying the number of readers and of thinkers, and in giving a certain stability to the mutable forms of oral speech, may be easily imagined. The vulgar translation of the Bible into English, is pronounced by Dr Lowth to be still the best standard of our language.

find various ingenious men, soon after the period in question, employed in prosecuting *experimental* inquiries; a species of study to which nothing analogous occurs in the history of ancient science.[1] The boldest and most successful of this new school was the celebrated Paracelsus; born in 1493, and consequently only ten years younger than Luther. "It is impossible to doubt," says Le Clerc, in his *History of Physic*, "that he possessed an extensive of knowledge of what is called the *Materia Medica*, and that he had employed much time in working on the animal, the vegetable, and the mineral substances of which it is composed. He seems, besides, to have tried an immense number of experiments in chemistry; but he has this great defect, that he studiously conceals or disguises the results of his long experience." The same author quotes from Paracelsus a remarkable expression, in which he calls the philosophy of Aristotle *a wooden foundation.* "He ought to have attempted," continues Le Clerc, "to have laid a better; but if he has not done it, he has at least, by discovering its weakness, invited his successors to look out for a firmer basis."[2]

Lord Bacon himself, while he censures the moral frailties of Paracelsus, and the blind empiricism of his followers, indirectly acknowledges the extent of his experimental information: "The ancient sophists may be said to have hid; but Paracelsus extinguished the light of nature. The sophists were only deserters of experience, but Paracelsus has betrayed it. At the same time, he is so far from understanding the right method of conducting experiments, or of recording their results, that he has added to the trouble and tediousness of experimenting. By wandering through the wilds of experience, his disciples sometimes stumble upon useful discoveries, not by reason, but by accident;—whence rashly proceeding to form theories, they carry the smoke and tarnish of their art along with them; and, like childish operators at the furnace, attempt to raise a structure of philosophy with a few experiments of distillation."

Two other circumstances, of a nature widely different from those hitherto enumerated, although, probably, in no small degree to be accounted for on the same principles, seconded, with an incalculable accession of power, the sudden impulse which the human mind had just received. The same century which the invention of printing, and the revival of letters have made for ever memorable, was also illustrated by the discovery of the New World, and of the passage to India by the Cape of Good Hope;—events which may be justly re-

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[1] "Hæc nostra (ut sæpe diximus) felicitatis cujusdam sunt potius quam facultatis, *et potius temporis partus quam ingenii.*" *Nov. Org.* Lib. i. c. xxiii.

[2] Histoire de la Médecine, (à la Haye, 1729,) p. 819.

garded as fixing a new era in the political and moral history of mankind; and which still continue to exert a growing influence over the general condition of our species. "It is an "era," as Raynal observes, "which gave rise to a revolution, not only in the commerce of nations, but in the manners, industry, and government of the world. At this period new connections were formed by the inhabitants of the most distant regions, for the supply of wants which they had never before experienced. The productions of climates situated under the equator, were consumed in countries bordering on the pole; the industry of the north was transplanted to the south; and the inhabitants of the west were clothed with the manufactures of the east; a general intercourse of opinions, laws and customs, diseases and remedies, virtues and vices, was established among men."

"Every thing," continues the same writer, "has changed, and must yet change more. But it is a question, whether the revolutions that are past, or those which must hereafter take place, have been, or can be, of any utility to the human race. Will they add to the tranquillity, to the enjoyments, and to the happiness of mankind? Can they improve our present state, or do they only change it?"

I have introduced this quotation, not with the design of attempting at present any reply to the very interesting question with which it concludes; but merely to convey some slight notion of the political and moral importance of the events in question. I cannot, however, forbear to remark, in addition to Raynal's eloquent and impressive summary, the inestimable treasure of new facts which these events have furnished for illustrating the versatile nature of man, and the history of civil society. In this respect (as Bacon has well observed) they have fully verified the Scripture prophecy, *multi pertransibunt et augebitur scientia;* or, in the still more emphatical words of our English version, "Many shall go to and fro, and knowledge shall be increased."[1] The same prediction may be applied to the gradual renewal (in proportion as modern governments became effectual in securing order and tranquillity) of that intercourse between the different states of Europe, which had, in a great measure, ceased during the anarchy and turbulence of the middle ages.

In consequence of these combined causes, aided by some others of secondary importance,[2]

[1] "Neque omittenda est prophetia Danielis de ultimis mundi temporibus; *multi pertransibunt et augebitur scientia:* Manifeste innuens et significans, esse in fatis, id est, in providentia, ut pertransitus mundi (qui per tot longinquas navigationes impletur plane, aut jam in opere esse videtur) et augmenta scientiarum in eandem ætatem incidant." *Nov. Org.* Lib. xciii.

[2] Such as the *accidental* inventions of the telescope and of the microscope. The powerful influence of these inventions may be easily conceived; not only in advancing the sciences of Astronomy and of Natural History, but in banishing many of the scholastic prejudices then universally prevalent. The effects of the telescope, in this respect, have been often remarked; but less attention has been given to those of the microscope,—

the Genius of the human race seems, all at once, to have awakened with renovated and giant strength, from his long sleep. In less than a century from the invention of printing, and the fall of the Eastern empire, Copernicus discovered the true theory of the planetary motions, and a very few years afterwards, was succeeded by the three great precursors of Newton,—Tycho Brahe, Kepler, and Galileo.

The step made by Copernicus may be justly regarded as one of the proudest triumphs of human reason ;—whether we consider the sagacity which enabled the author to obviate, to his own satisfaction, the many plausible objections which must have presented themselves against his conclusions, at a period when the theory of motion was so imperfectly understood ; or the bold spirit of inquiry which encouraged him to exercise his private judgment, in opposition to the authority of Aristotle,—to the decrees of the church of Rome,—and to the universal belief of the learned, during a long succession of ages. He appears, indeed, to have well merited the encomium bestowed on him by Kepler, when he calls him "a man of vast genius, and, what is of still greater moment in these researches, a man of a free mind."

The establishment of the Copernican system, beside the new field of study which it opened to Astronomers, must have had great effects on philosophy in all its branches, by inspir-

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which, however, it is probable, contributed not a little to prepare the way for the modern revival of the Atomic or Corpuscular Philosophy, by Bacon, Gassendi, and Newton. That, on the mind of Bacon, the wonders disclosed by the microscope produced a strong impression in favour of the Epicurean physics, may be inferred from his own words. "Perspicillum (microscopicum) si vidisset Democritus, exsiluisset forte ; et modum videndi Atomum (quem ille invisibilem omnino affirmavit) inventum fuisse putasset." *Nov. Org.* Lib. ii. § 39.

We are told in the life of Galileo, that when the telescope was invented, some individuals carried to so great a length their devotion to Aristotle, that they positively refused to look through that instrument : so averse were they to open their eyes to any truths inconsistent with their favourite creed. (*Vita del Galileo*, Venezia, 1744.) It is amusing to find some other followers of the Stagirite, a very few years afterwards, when they found it impossible any longer to call in question the evidence of sense, asserting that it was from a passage in Aristotle (where he attempts to explain why stars become visible in the day-time when viewed from the bottom of a deep well) that the invention of the telescope was borrowed. The two facts, when combined together, exhibit a truly characteristical portrait of one of the most fatal weaknesses incident to humanity ; and form a moral apologue, daily exemplified on subjects of still nearer and higher interest than the phenomena of the heavens.

In ascribing to *accident* the inventions of the telescope and of the microscope, I have expressed myself in conformity to common language ; but it ought not to be overlooked, that an invention may be accidental with respect to the particular author, and yet may be the natural result of the circumstances of society at the period when it took place. As to the instruments in question, the combination of lenses employed in their structure is so simple, that it could scarcely escape the notice of *all* the experimenters and mechanicians of that busy and inquisitive age. A similar remark has been made by Condorçet concerning the invention of printing. "L'invention de l'Imprimerie a sans doute avancé le progrès de l'espéce humaine ; mais cette invention étoit elle-même une suite de l'usage de la lecture répandu dans un grand nombre de pays." *Vie du Turgot.*

ing those sanguine prospects of future improvement, which stimulate curiosity, and invigorate the inventive powers. It afforded to the common sense, even of the illiterate, a palpable and incontrovertible proof, that the ancients had not exhausted the stock of possible discoveries; and that, in matters of science, the creed of the Romish church was not infallible. In the conclusion of one of Kepler's works, we perceive the influence of these prospects on his mind. "Hæc et cetera hujusmodi latent in pandectis ævi sequentis, non antea discenda, quam librum hunc Deus arbiter seculorum recluserit mortalibus." [1]

I have hitherto taken no notice of the effects of the revival of letters on Metaphysical, Moral, or Political science. The truth is, that little deserving of our attention occurs in any of these departments prior to the seventeenth century; and nothing which bears the most remote analogy to the rapid strides made, during the sixteenth, in mathematics, astronomy, and physics. The influence, indeed, of the Reformation on the *practical* doctrines of ethics appears to have been great and immediate. We may judge of this from a passage in Melanchthon, where he combats the pernicious and impious tenets of those theologians who maintained, that moral distinctions are created entirely by the arbitrary and revealed will of God. In opposition to this heresy he expresses himself in these memorable words:— "Wherefore our decision is this; that those precepts which learned men have committed to writing, transcribing them from the common reason and common feelings of human nature, are to be accounted as not less divine, than those contained in the tables given to Moses; and that it could not be the intention of our Maker to supersede, by a law graven upon stone, that which is written with his own finger on the table of the heart." [2]—This language was, undoubtedly, a most important step towards a just system of Moral Philosophy; but still, like the other steps of the reformers, it was only a return to common sense, and to the genuine spirit of Christianity, from the dogmas imposed on the credulity of mankind by an ambitious priesthood. [3] Many years were yet to elapse, before any at-

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[1] *Epit. Astron. Copernic.*

[2] Proinde sic statuimus, nihilo minus divina præcepta esse ea, quæ a sensu communi et naturæ judicio mutuati docti homines gentiles literis mandarunt, quam quæ extant in ipsis saxeis Mosis tabulis. Neque ille ipse cælestis Pater pluris a nobis fieri eas leges voluit, quas in saxo scripsit, quam quas in ipsos animorum nostrorum sensus impresserat."

Not having it in my power at present to consult Melanchthon's works, I have transcribed the foregoing paragraph on the authority of a learned German Professor, Christ. Meiners. See his *Historia Doctrinæ de Vero Deo.* Lemgoviæ, 1780, p. 12.

[3] It is observed by Dr Cudworth, that the doctrine which refers the origin of moral distinctions to the arbitrary appointment of the Deity, was strongly reprobated by the ancient fathers of the Christian church, and

tempts were to be made to trace, with analytical accuracy, the moral phenomena of human life to their first principles in the constitution and condition of man; or even to disentangle the plain and practical lessions of ethics from the speculative and controverted articles of theological systems. [1]

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that "it crept up afterward in the scholastic ages; Occam being among the first that maintained, that there is no act evil, but as it is prohibited by God, and which cannot be made good, if it be commanded by him. In this doctrine he was quickly followed by Petrus Alliacus, Andreas de Novo Castro, and others." See *Treatise of Immutable Morality*.

It is pleasing to remark, how very generally the heresy here ascribed to Occam is now reprobated by good men of all persuasions. The Catholics have even begun to recriminate on the Reformers as the first broachers of it; and it is to be regretted, that in *some* of the writings of the latter, too near approaches to it are to be found. The truth is (as Burnet long ago observed), that the effects of the reformation have not been confined to the reformed churches;—to which it may be added, that both Catholics and Protestants have, since that era, profited very largely by the general progress of the sciences and of human reason.

I quote the following sentence from a highly respectable Catholic writer on the law of nature and nations:— "Qui rationem exsulare jubent a moralibus præceptis quæ in sacris literis traduntur, et in absurdam enormemque Lutheri sententiam imprudentes incidunt (quam egregie et elegantissime refutavit Melchior Canus *Loc. Theolog*. Lib. ix. and x.) et ea docent, quæ si sectatores inveniant moralia omnia susque deque miscere, et revelationem ipsam inutilem omnino et inefficacem reddere possent." (Lampredi Florentini *Juris Naturæ et Gentium Theoremata*, Tom. II. p. 195. Pisis, 1782.) For the continuation of the passage, which would do credit to the most liberal protestant, I must refer to the original work. The zeal of Luther for the doctrine of the Nominalists had probably prepossessed him, in his early years, in favour of some of the theological tenets of Occam; and afterwards prevented him from testifying his disapprobation of them so explicitly and decidedly as Melanchthon and other reformers have done.

[1] "The theological system (says the learned and judicious Mosheim) that *now* prevails in the Lutheran academies, is not of the same tenor or spirit with that which was adopted in the infancy of the Reformation. The glorious defenders of religious liberty, to whom we owe the various blessings of the Reformation, could not, at once, behold the truth in all its lustre, and in all its extent; but, as usually happens to persons that have been long accustomed to the darkness of ignorance, their approaches towards knowledge were but slow, and their views of things but imperfect." (Maclaine's *Transl. of Mosheim*. London, 2d Ed. Vol. IV. p. 19.) He afterwards mentions one of Luther's early disciples, (Amsdorff,) "who was so far transported and infatuated by his excessive zeal for the supposed doctrine of his master, as to maintain, that *good works are an impediment to salvation*." Ibid. p. 39.

Mosheim, after remarking that "there are more excellent rules of conduct in the few practical productions of Luther and Melanchthon, than are to be found in the innumerable volumes of all the ancient *casuists* and *moralisers*," candidly acknowledges, "that the notions of these great men concerning the important science of morality were far from being sufficiently accurate or extensive. Melanchthon himself, whose exquisite judgment rendered him peculiarly capable of reducing into a compendious system the elements of every science, never seems to have thought of treating morals in this manner; but has inserted, on the contrary, all his practical rules and instructions, under the theological articles that relate to the *law, sin, free-will, faith, hope, and charity*." Mosheim's *Eccles. Hist*. Vol. IV. pp. 23, 24.

The same author elsewhere observes, that "the progress of morality among the reformed was obstructed by the very same means that retarded its improvement among the Lutherans; and that it was left in a rude and imperfect state by Calvin and his associates. It was neglected amidst the tumult of controversy; and, while every pen was drawn to maintain certain systems of doctrine, few were employed in cultivating that master-science which has *virtue, life*, and *manners* for its objects." Ibid. pp. 120, 121.

A similar observation may be applied to the powerful appeals, in the early protestant writers, to the moral judgment and moral feelings of the human race, from those casuistical subtleties, with which the schoolmen and monks of the middle ages had studied to obscure the light of nature, and to stifle the voice of conscience. These subtleties were precisely analogous in their spirit to the *pia et religiosa calliditas*, afterwards adopted in the casuistry of the Jesuits, and so inimitably exposed by Pascal in the *Provincial Letters*. The arguments against them employed by the Reformers, cannot, in strict propriety, be considered as positive accessions to the stock of human knowledge; but what scientific discoveries can be compared to them in value! [1]

From this period may be dated the decline [2] of that worst of all heresies of the Romish church, which, by opposing Revelation to Reason, endeavoured to extinguish the light of both; and the absurdity (so happily described by Locke) became every day more manifest, of attempting "to persuade men to put out their eyes, that they might the better receive the remote light of an invisible star by a telescope."

In the meantime, a powerful obstacle to the progress of practical morality and of sound policy, was superadded to those previously existing in Catholic countries, by the rapid growth and extensive influence of the Machiavellian school. The founder of this new sect (or to speak more correctly, the systematizer and apostle of its doctrines) was born as early as 1469, that is, about ten years before Luther; and, like that reformer, acquired, by the commanding superiority of his genius, an astonishing ascendant (though of a very different nature) over the minds of his followers. No writer, certainly, either in ancient or in modern times, has ever united, in a more remarkable degree, a greater variety of the most dissimilar and seemingly the most discordant gifts and attainments;—a profound acquaint-

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[1] "Et tamen ni doctores, *angelici, cherubici, seraphici* non modo universam philosophiam ac theologiam erroribus quam plurimis inquinarunt; verum etiam in philosophiam moralem invexere sacerrima ista principia *probabilismi, methodi dirigendi intentionem, reservationis mentalis, peccati philosophici*, quibus *Jesuitæ* etiamnum mirifice delectantur." Heinecc. *Elem. Histor. Phil.* § cii. See also the references.

With respect to the ethics of the Jesuits, which exhibit a very fair picture of the general state of that science, prior to the Reformation, See the *Provincial Letters;* Mosheim's *Ecclesiastical History*, Vol. IV. p. 354; Dornford's *Translation of Putter's Historical Developement of the present Political Constitution of the Germanic Empire*, (Vol. II. p. 6.); and the Appendix to Penrose's *Bampton Lectures*.

[2] I have said, *the decline of this heresy*, for it was by no means *immediately* extirpated even in the reformed churches. "As late as the year 1598, Daniel Hofman, Professor of Divinity in the University of Helmstadt, laying hold of some particular opinions of Luther, extravagantly maintained, that philosophy was the mortal enemy of religion; that truth was divisible into two branches, the one *philosophical* and the other *theological;* and that what was *true* in philosophy was *false* in theology." Mosheim, Vol. IV. p. 18.

ance with all those arts of dissimulation and intrigue, which, in the petty cabinets of Italy, were then universally confounded with political wisdom ;—an imagination familiarized to the cool contemplation of whatever is perfidious or atrocious in the history of conspirators and of tyrants ;—combined with a graphical skill in holding up to laughter the comparatively harmless follies of ordinary life. His dramatic humour has been often compared to that of Moliere ; but it resembles it rather in comic force, than in benevolent gaiety, or in chastened morality. Such as it is, however, it forms an extraordinary contrast to that strength of intellectual character, which, in one page, reminds us of the deep sense of Tacitus, and in the next, of the dark and infernal policy of Cæsar Borgia. To all this must be superadded a purity of taste, which has enabled him, as an historian, to rival the severe simplicity of the Grecian masters ; and a sagacity in combining historical facts, which was afterwards to afford lights to the school of Montesquieu.

Eminent, however, as the talents of Machiavel unquestionably were, he cannot be numbered among the benefactors of mankind. In none of his writings, does he exhibit any marks of that lively sympathy with the fortunes of the human race, or of that warm zeal for the interests of truth and justice, without the guidance of which, the highest mental endowments, when applied to moral or to political researches, are in perpetual danger of mistaking their way. What is still more remarkable, he seems to have been altogether blind to the mighty changes in human affairs, which, in consequence of the recent invention of printing, were about to result from the progress of Reason and the diffusion of Knowledge. Through the whole of his *Prince* (the most noted as well as one of the latest of his publications) he proceeds on the supposition, that the sovereign has no other object in governing, but his own advantage ; the very circumstance which, in the judgment of Aristotle, constitutes the essence of the worst species of tyranny. [1] He assumes also the possibility of retaining mankind in perpetual bondage by the old policy of the *double doctrine ;* or, in other words, by enlightening the few, and hoodwinking the many ;—a policy less or more practised by statesmen in all ages and countries ; but which (wherever the freedom of the press is respected) cannot fail, by the insult it offers to the discernment of the multitude, to increase the insecurity of those who have the weakness to employ it. It has been contended, indeed, by some of Machiavel's apologists, that his real object in unfolding and systematising the mysteries of *King-Craft,* was to point out indirectly to the governed the

[1] " There is a third kind of tyranny, which most properly deserves that odious name, and which stands in direct opposition to royalty; it takes place when one man, the worst perhaps and basest in the country, governs a kingdom, with no other view than the advantage of himself and his family." Aristotle's *Politics,* Book vi. chap. x. See Dr Gillies's Translation.

means by which the encroachments of their rulers might be most effectually resisted; and, at the same time, to satirize, under the ironical mask of loyal and courtly admonition, the characteristical vices of princes.[1] But, although this hypothesis has been sanctioned by several distinguished names, and derives some verisimilitude from various incidents in the author's life, it will be found, on examination, quite untenable; and accordingly it is now, I believe, very generally rejected. One thing is certain, that if such were actually Machiavel's views, they were much too refined for the capacity of his royal pupils. By many of these his book has been adopted as a manual for daily use; but I have never heard of a single instance, in which it has been regarded by this class of students as a disguised panegyric upon liberty and virtue. The question concerning the *motives* of the author is surely of little moment, when experience has enabled us to pronounce so decidedly on the practical *effects* of his precepts.

"About the period of the Reformation," says Condorcet, "the principles of religious Machiavelism had become the *only* creed of princes, of ministers, and of pontiffs; and the same opinions had contributed to corrupt philosophy. What code, indeed, of morals," he adds, "was to be expected from a system, of which one of the principles is,—that it is necessary to support the morality of the people by false pretences,—and that men of enlightened minds have a right to retain others in the chains from which they have themselves contrived to escape!" The fact is perhaps stated in terms somewhat too unqualified; but there are the best reasons for believing, that the exceptions were few, when compared with the general proposition.

The consequences of the prevalence of such a creed among the rulers of mankind were such as might be expected. "Infamous crimes, assassinations, and poisonings (says a French historian,) prevailed more than ever. They were thought to be the growth of Italy, where the rage and weakness of the opposite factions conspired to multiply them. Morality gradually disappeared, and with it all security in the intercourse of life. The first principles of duty were obliterated by the joint influence of atheism and of superstition."[2]

And here, may I be permitted to caution my readers against the common error of confounding the double doctrine of Machiavellian politicians, with the benevolent reverence for established opinions, manifested in the noted maxim of Fontenelle,—"that a wise man, even when his hand was full of truths, would often content himself with opening his little finger?" Of the advocates for the former, it may be justly said, that "they love darkness

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[1] See Note C.

[2] Millot.

rather than light, *because their deeds are evil;*" well knowing (if I may borrow the words of Bacon), "that the open day-light doth not shew the masks and mummeries, and triumphs of the world, half so stately as candle-light." The philosopher, on the other hand, who is duly impressed with the latter, may be compared to the oculist, who, after removing the cataract of his patient, prepares the still irritable eye, by the glimmering dawn of a darkened apartment, for enjoying in safety the light of day. [1]

Machiavel is well known to have been, at bottom, no friend to the priesthood; and his character has been stigmatized by many of the order with the most opprobrious epithets. It is nevertheless certain, that to *his* maxims the royal defenders of the catholic faith have been indebted for the spirit of that policy which they have uniformly opposed to the innovations of the Reformers. The *Prince* was a favourite book of the Emperor Charles V.; and was called the *Bible* of Catharine of Medicis. At the court of the latter, while Regent of France, those who approached her are said to have professed openly its most atrocious maxims; particularly *that* which recommends to sovereigns not to commit crimes by halves. The Italian cardinals, who are supposed to have been the secret instigators of the massacre of St Bartholomew, were bred in the same school. [2]

It is observed by Mr Hume, that "there is scarcely any maxim in the *Prince*, which subsequent experience has not entirely refuted." "Machiavel," says the same writer, "was certainly a great genius; but having confined his study to the furious and tyrannical governments of ancient times, or to the little disorderly principalities of Italy, his reasonings,

[1] How strange is the following misrepresentation of Fontenelle's fine and deep saying, by the comparatively coarse hand of the Baron de Grimm! "Il disoit, que s'il êut tenu la vérité dans ses mains comme un oiseau, il l'auroit etouffée, tant il regardoit le plus beau présent du ciel inutile et dangereux pour le genre humain." (*Mémoires Historiques*, &c. par le Baron de Grimm. Londres, 1814. Tome I. p. 340.) Of the complete inconsistency of this statement, not only with the testimony of his most authentic biographers, but with the general tenor both of his life and writings, a judgment may be formed from an expression of D'Alembert, in his very ingenious and philosophical parallel between Fontenelle and La Motte. "Tous deux ont porté trop loin leur revolte décidée, quoique douce en apparence, contre les dieux et les lois du Parnasse; mais la liberté des opinions de la Motte semble tenir plus intimement à l'intérêt personnel qu'il avoit de les soutenir; et la liberté des opinions de Fontenelle *à l'intérêt général, peut être quelquefois mal entendu, qu'il prenoit au progrès de la raison dans tous les genres.*" What follows may be regarded in the light of a comment on the maxim above quoted: "La finesse de la Motte est plus développée, celle de Fontenelle laisse plus à deviner à son lecteur. La Motte, sans jamais en trop dire, n'oublie rien de ce que son sujet lui présente, met habilement tout en œuvre, et semble craindre perdre par des réticences trop subtiles quelqu'un de ses avantages; Fontenelle, sans jamais être obscur, excepté pour ceux qui ne meritent pas même qu'on soit clair, se menage à la fois et le plaisir de sous-entendre, et celui d'espérer qu'il sera pleinement entendu par ceux qui en sont dignes." *Eloge de la Motte.*

[2] Voltaire, *Essay on Universal History.*

especially upon monarchical governments, have been found extremely defective. The errors of this politician proceeded, in a great measure, from his having lived in too early an age of the world, to be a good judge of political truth." [1]

To these very judicious remarks, it may be added, that the bent of Machiavel's mind seems to have disposed him much more strongly to combine and to generalize his historical reading, than to remount to the first principles of political science, in the constitution of human nature, and in the immutable truths of morality. His conclusions, accordingly, ingenious and refined as they commonly are, amount to little more (with a few very splendid exceptions) than empirical results from the events of past ages. To the student of ancient history they may be often both interesting and instructive; but, to the modern politician, the most important lesson they afford is, the danger, in the present circumstances of the world, of trusting to such results, as maxims of universal application, or of permanent utility.

The progress of political philosophy, and along with it of morality and good order, in every part of Europe, since the period of which I am now speaking, forms so pleasing a comment on the profligate and short-sighted policy of Machiavel, that I cannot help pausing for a moment to remark the fact. In stating it, I shall avail myself of the words of the same profound writer, whose strictures on Machiavel's *Prince* I had already occasion to quote. "Though all kinds of government," says Mr Hume, "be improved in modern times, yet monarchical government seems to have made the greatest advances towards perfection. It may now be affirmed of civilized monarchies, what was formerly said of republics alone, that they are a government of laws, not of men. They are found susceptible of order, method, and constancy, to a surprising degree. Property is there secure, industry encouraged, the arts flourish, and the prince lives secure among his subjects, like a father among his children. There are, perhaps, and have been for two centuries, near two hundred absolute princes, great and small, in Europe; and allowing twenty years to each reign, we may suppose that there have been in the whole two thousand monarchs or *tyrants*, as the Greeks would have called them. Yet of these there has not been one, not even Philip II. of Spain, so bad as Tiberius, Caligula, Nero, or Domitian, who were four in twelve among the Roman emperors." [2]

For this very remarkable fact, it seems difficult to assign any cause equal to the effect, but the increased diffusion of knowledge (imperfect, alas! as this diffusion still is) by means of the Press; which, while it has raised, in free states, a growing bulwark against the oppression of rulers, in the light and spirit of the people, has, even under the most absolute governments,

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[1] *Essay on Civil Liberty.* [2] Ibid.

had a powerful influence—by teaching princes to regard the wealth and prosperity and instruction of their subjects as the firmest basis of their grandeur—in directing their attention to objects of national and permanent utility. How encouraging the prospect thus opened of the future history of the world! And what a motive to animate the ambition of those, who, in the solitude of the closet, aspire to bequeath their contributions, how slender soever, to the progressive mass of human improvement and happiness!

In the bright constellation of scholars, historians, artists, and wits, who shed so strong a lustre on Italy during that splendid period of its history which commences with the revival of letters, it is surprising how few names occur, which it is possible to connect, by any palpable link, with the philosophical or political speculations of the present times. As an original and profound thinker, the genius of Machiavel completely eclipses that of all his contemporaries. Not that Italy was then destitute of writers who pretended to the character of philosophers; but as their attempts were, in general, limited to the exclusive illustration and defence of some one or other of the ancient systems for which they had conceived a predilection, they added but little of their own to the stock of useful knowledge; and are now remembered chiefly from the occasional recurrence of their names in the catalogues of the curious, or in works of philological erudition. The zeal of Cardinal Bessarion, and of Marsilius Ficinus, for the revival of the Platonic philosophy, was more peculiarly remarkable; and, at one time, produced so general an impression, as to alarm the followers of Aristotle for the tottering authority of their master. If we may credit Launoius, this great revolution was on the point of being actually accomplished, when Cardinal Bellarmine warned Pope Clement VIII. of the peculiar danger of shewing any favour to a philosopher whose opinions approached so nearly as those of Plato to the truths revealed in the Gospel. In what manner Bellarmine connected his conclusions with his premises, we are not informed. To those who are uninitiated in the mysteries of the conclave, his inference would certainly appear much less logical than that of the old Roman Pagans, who petitioned the Senate to condemn the works of Cicero to the flames, as they predisposed the minds of those who read them for embracing the Christian faith.

By a small band of bolder innovators, belonging to this golden age of Italian literature, the Aristotelian doctrines were more directly and powerfully assailed. Laurentius Valla, Marius Nizolius, and Franciscus Patricius,[1] have all of them transmitted their names to pos-

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[1] His *Discussiones Peripateticæ* were printed at Venice in 1571. Another work, entitled *Nova de Universis Philosophia*, also printed at Venice, appeared in 1593. I have never happened to meet with either;

terity as philosophical reformers, and, in particular, as revolters against the authority of the Stagirite. Of the individuals just mentioned, Nizolius is the only one who seems entitled to maintain a permanent place in the annals of modern science. His principal work, entitled *Antibarbarus*,[1] is not only a bold invective against the prevailing ignorance and barbarism of the schools, but contains so able an argument against the then fashionable doctrine of the Realists concerning *general ideas*, that Leibnitz thought it worth while, a century afterwards, to republish it, with the addition of a long and valuable preface written by himself.

At the same period with Franciscus Patricius, flourished another learned Italian, Albericus Gentilis, whose writings seem to have attracted more notice in England and Germany than in his own country. His attachment to the reformed faith having driven him from Italy, he sought an asylum at Oxford, where he published, in 1588, a book *de Jure Belli*; and where he appears to have read lectures on Natural Jurisprudence, under the sanction of the University. His name has already sunk into almost total oblivion; and I should certainly not have mentioned it on the present occasion, were it not for his indisputable merits as the precursor of Grotius, in a department of study which, forty years afterwards, the celebrated treatise *De Jure Belli et Pacis* was to raise to so conspicuous a rank among the branches of academical education. The avowed aim of this new science, when combined with the anxiety of Gentilis to counteract the effect of Machiavel's *Prince*, by representing it as a warning to subjects rather than as a manual of instruction for their rulers, may be regarded as satisfactory evidence of the growing influence, even at that era, of better ethical principles than those commonly imputed to the Florentine Secretary.[2]

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but from the account given of the author by Thuanus, he does not seem to have attracted that notice from his contemporaries, to which his learning and talents entitled him. (Thuan. *Hist.* Lib. cxix. xvii.) His *Discussiones Peripateticæ*, are mentioned by Brucker in the following terms: "*Opus egregium, doctum, varium, luculentum, sed invidia odioque in Aristotelem plenum satis superque.*" (*Hist. Phil.* Tom. IV. p. 425.) The same very laborious and candid writer acknowledges the assistance he had derived from *Patricius* in his account of the Peripatetic philosophy.—"In qua tractatione fatemur egregiam enitere Patricii doctrinam, ingenii elegantiam prorsus admirabilem, et quod primo loco ponendum est, insolitam veteris philosophiæ cognitionem, cujus ope nos Peripateticæ disciplinæ historiæ multoties lucem attulisse, grati suis locis professi sumus." Ibid. p. 426.

[1] *Antibarbarus, sive de Veris Principiis et Vera Ratione Philosophandi contra Pseudo-philosophos.* Parmæ, 1553. "Les faux philosophes," dit Fontenelle, "etoient tous les scholastiques passés et présens; et Nizolius s'élève avec la dernière hardiesse contre leurs idées monstrueuses et leur langage barbare. La longue et constante admiration qu'on avoit eu pour Aristote, ne prouvoit, disoit-il, que la multitude des sots et la durée de la sottise." The merits of this writer are much too lightly estimated by Brucker. See *Hist. Phil.* Tom. IV. Pars I. pp. 91, 92.

[2] The claims of Albericus Gentilis to be regarded as the father of *Natural Jurisprudence*, are strongly asserted by his countryman Lampredi, in his very judicious and elegant work, entitled, *Juris Publici Theoremata*,

The only other Italian of whom I shall take notice at present, is Campanella;[1] a philosopher now remembered chiefly in consequence of his eccentric character and eventful life, but of whom Leibnitz has spoken in terms of such high admiration, as to place him in the same line with Bacon. After looking into several of his works with some attention, I must confess, I am at a loss to conceive upon what grounds the eulogy of Leibnitz proceeds; but as it is difficult to suppose, that the praise of this great man was, in any instance, the result of mere caprice, I shall put it in the power of my readers to judge for themselves, by subjoining a faithful translation of his words. I do this the more willingly, as the passage itself (whatever may be thought of the critical judgments pronounced in it), contains some general remarks on *intellectual character*, which are in every respect worthy of the author.

" Some men, in conducting operations where an attention to minutiæ is requisite, discover a mind vigorous, subtile, and versatile, and seem to be equal to any undertaking how arduous soever. But when they are called upon to act on a greater scale, they hesitate and are lost in their own meditations; distrustful of their judgment, and conscious of their incompetency to the scene in which they are placed: men, in a word, possessed of a genius rather acute than comprehensive. A similar difference may be traced among authors. What can be more acute than Descartes in Physics, or than Hobbes in Morals! And yet, if the one be compared with Bacon, and the other with Campanella, the former writers seem to grovel upon the earth,—the latter to soar to the Heavens, by the vastness of their conceptions, their plans, and their enterprises, and to aim at objects beyond the reach of the human powers. The former, accordingly, are best fitted for delivering the first elements of knowledge, the latter for establishing conclusions of important and general application."[2]

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published at Pisa in 1782. " Hic primus jus aliquod Belli et esse et tradi posse excogitavit, et Belli et Pacis regulas explanavit primus, et fortasse in causa fuit cur Grotius opus suum conscribere aggrederetur; dignus sane qui præ ceteris memoretur, Italiæ enim, in qua ortus erat, et unde Juris Romani disciplinam hauserat, gloriam auxit, effecitque ut quæ fuerat bonarum artium omnium restitutrix et altrix, eadem esset et prima Jurisprudentiæ Naturalis magistra."

[1] Born 1568, died 1639.

[2] Leibnit. *Opera*, Vol. vi. p. 303, Ed. Dutens.—It is probable that, in the above passage, Leibnitz alluded more to the elevated tone of Campanella's reasoning on moral and political subjects, when contrasted with that of Hobbes, than to the intellectual superiority of the former writer above the latter. No philosopher, certainly, has spoken with more reverence than Campanella has done, on various occasions, of the dignity of human nature. A remarkable instance of this occurs in his eloquent comparison of the *human hand* with the organs of touch in other animals. (*Vide* Campan. *Physiolog.* cap. xx. Art. 2.) Of his *Political Aphorisms* (which form the third part of his treatise on *Morals*), a sufficient idea for our purpose is conveyed by the concluding *corollary*, " Probitas custodit regem populosque; non autem indocta Machiavellistarum astutia." On the other hand, Campanella's works abound with immoralities and extravagancies far exceeding those of

The annals of France, during this period, present very scanty materials for the History of Philosophy. The name of the Chancellor De l'Hopital, however, must not be passed over in silence. As an author, he does not rank high; nor does he seem to have at all valued himself on the careless effusions of his literary hours; but, as an upright and virtuous magistrate, he has left behind him a reputation unrivalled to this day.[1] His wise and indulgent principles on the subject of religious liberty, and the steadiness with which he adhered to them, under circumstances of extraordinary difficulty and danger, exhibit a splendid contrast to the cruel intolerance, which, a few years before, had disgraced the character of an illustrious Chancellor of England. The same philosophical and truly catholic spirit distinguished his friend, the President de Thou;[2] and gives the principal charm to the justly admired preface prefixed to his history. In tracing the progress of the human mind during the sixteenth century, such insulated and anomalous examples of the triumph of reason over superstition and bigotry, deserve attention, not less than what is due, in a history of the experimental arts, to Friar Bacon's early anticipation of gun-powder, and of the telescope.

Contemporary with these great men was Bodin (or Bodinus),[3] an eminent French lawyer, who appears to have been one of the first that united a philosophical turn of thinking with an extensive knowledge of jurisprudence and of history. His learning is often ill digested, and his conclusions still oftener rash and unsound: yet it is but justice to him to acknowledge, that, in his views of the philosophy of law, he has approached very nearly to some leading ideas of Lord Bacon;[4] while, in his refined combinations of historical facts, he has more than once struck into a train of speculation, bearing a strong resemblance to that afterwards pursued by Montesquieu.[5] Of this resemblance, so remarkable an instance oc-

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Hobbes. In his idea of a perfect commonwealth (to which he gives the name of *Civitas Solis*), the impurity of his imagination, and the unsoundness of his judgment, are equally conspicuous. He recommends, under certain regulations, a community of women; and, in every thing connected with procreation, lays great stress on the opinions of astrologers.

[1] Magistrat au-dessus de tout eloge; et d'après lequel on a jugé tous ceux qui ont osé s'asseoir sur ce même tribunal sans avoir son courage ni ses lumières." Henault, *Abrégé Chronologique*.

[2] "One cannot help admiring," says Dr Jortin, "the *decent* manner, in which the illustrious Thuanus hath spoken of Calvin:" Acri vir ac vehementi ingenio, et admirabili facundia præditus; tum inter protestantes magni nominis Theologus." (*Life of Erasmus*, p. 555.) The same writer has remarked the *great decency and moderation* with which Thuanus speaks of Luther. *Ibid*. p. 113.

[3] Born 1530, died 1596.

[4] See, in particular, the preface to his book, entitled *Methodus ad facilem Historiarum cognitionem*.

[5] See the work *De la République, passim*. In this treatise there are two chapters singularly curious, considering the time when they were written; the second and third chapters of the sixth book. The first is entitled *Des Finances;* the second, *Le Moyen d'empêcher que les Monnoyes soyent alterées de Prix ou falsifiées*. The reasonings of the Author on various points there treated of will be apt to excite a smile among those

curs in his chapter on the moral effects of Climate, and on the attention due to this circumstance by the legislator, that it has repeatedly subjected the author of *the Spirit of Laws* (but in my opinion without any good reason) to the imputation of plagiarism.[1] A resemblance to Montesquieu, still more honourable to Bodinus, may be traced in their common attachment to religious as well as to civil liberty. To have caught, in the sixteenth century somewhat of the philosophical spirit of the eighteenth, reflects less credit on the force of his mind, than to have imbibed, in the midst of the theological controversies of his age, those lessons of mutual forbearance and charity, which a long and sad experience of the fatal effects of persecution has to this day so imperfectly taught to the most enlightened nations of Europe.

As a specimen of the liberal and moderate views of this philosophical politician, I shall quote two short passages from his Treatise *De la République,* which seem to me objects of considerable curiosity, when contrasted with the general spirit of the age in which they were written. The first relates to liberty of conscience, for which he was a strenuous and intrepid advocate, not only in his publications, but as a member of the *Etats Géneraux*, assembled at Blois in 1576. " The mightier that a man is (says Bodin) the more justly and temperately he ought to behave himself towards all men, but especially towards his subjects. Wherefore the senate and people of Basil did wisely, who, having renounced the Bishop of Rome's religion, would not, upon the sudden, thrust the monks and nuns, with the other religious persons, out of their abbeys and monasteries, but only took order, that, as they died, they should die both for themselves and their successors, expressly forbidding any new to be chosen in their places, so that, by that means, their colleges might, by little and little, by the death of the fellows, be extinguished. Whereby it came to pass, that all the rest of the Carthusians, of their own accord, forsaking their cloisters, yet one of them all alone for a long time remained therein, quietly and without any disturbance, holding the right of his convent, being never enforced to change either his place, or habit, or old ceremonies, or religion before by him received. The like order was taken at Coire in the diet

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who have studied the *Inquiry into the Wealth of Nations;* but it reflects no small credit on a lawyer of the sixteenth century to have subjected such questions to philosophical examination; and to have formed so just a conception, as Bodin appears evidently to have done, not only of the object, but of the importance of the modern science of political economy.

Thuanus speaks highly of Bodin's dissertations *De re Monetaria,* which I have never seen.—The same historian thus expresses himself with respect to the work *De Republica :* " Opus in quo ut omni scientiarum genere non tincti sed imbuti ingenii fidem fecit, sic nonnullis, qui recte judicant, non omnino ab *ostentationis innato genti vitio* vacuum se probavit. *Hist.* Lib. cxvii. ix.

[1] See Note D.

of the Grisons; wherein it was decreed, that the ministers of the reformed religion should be maintained of the profits and revenues of the church, the religious men nevertheless still remaining in their cloisters and convents, to be by their death suppressed, they being now prohibited to choose any new instead of them which died. By which means, they which professed the new religion, and they who professed the old, were both provided for."[1]

The aim of the chapter from which I have extracted the foregoing passage, is to shew, that "it is a most dangerous thing, at one and the same time, to change the form, laws, and customs of a commonwealth." The scope of the author's reasonings may be judged of from the concluding paragraph.

"We ought then, in the government of a well ordered estate and commonwealth, to imitate and follow the great God of Nature, who in all things proceedeth easily, and by little and little; who of a little seed causeth to grow a tree for height and greatness, right admirable, and yet for all that insensibly; and still by means conjoining the extremities of nature, as by putting the spring between winter and summer, and autumn betwixt summer and winter, moderating the extremities of the terms and seasons, with the self-same wisdom which it useth in all other things also, and that in such sort, as that no violent force or course therein appeareth."[2]

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[1] Book iv. chap. iii.—The book from which this quotation is taken was published only twenty-three years after the murder of Servetus at Geneva; an event which leaves so deep a stain on the memory not only of Calvin, but on that of the milder and more charitable Melanchthon. The epistle of the latter to Bullinger, where he applauds the conduct of the judges who condemned to the flames this incorrigible heretic, affords the most decisive of all proofs, how remote the sentiments of the most enlightened Fathers of the Reformation were from those Christian and philosophical principles of toleration, to which their noble exertions have gradually, and now almost universally, led the way.

[2] *Ibid.*—The substance of the above reflection has been compressed by Bacon into the following well known aphorisms.

"Time is the greatest innovator; shall we then not imitate time?

"What innovator imitates time, which innovates so silently as to mock the sense?"

The resemblance between the two passages is still more striking in the Latin versions of their respective authors.

"Deum igitur præpotentem naturæ parentem imitemur, qui omnia paulatim: namque semina perquam exigua in arbores excelsas excrescere jubet, idque tam occultè ut nemo sentiat." Bodinus.

"Novator maximus tempus; quidni igitur tempus imitemur?

"Quis novator tempus imitatur, quod novationes ita insinuat, ut sensus fallant?" Bacon.

The Treatise of Bodin *De la République* (by far the most important of his works) was first printed at Paris in 1576, and was reprinted seven times in the space of three years. It was translated into Latin by the author himself; with a view chiefly (as is said) to the accommodation of the scholars of England, among whom it was so highly esteemed, that lectures upon it were given in the University of Cambridge, as early as 1580. In 1579, Bodin visited London in the *suite* of the Duc d'Alençon; a circumstance which probably contributed not a little to recommend his writings, so very soon after their publication, to the attention of our country-

Notwithstanding these wise and enlightened maxims, it must be owned, on the other hand, that Bodin has indulged himself in various speculations, which would expose a writer of the present times to the imputation of insanity. One of the most extraordinary of these, is his elaborate argument to prove, that, in a well constituted state, the father should possess the right of life and death over his children;—a paradox which forms an unaccountable contrast to the general tone of humanity which characterizes his opinions. Of the extent of his credulity on the subject of witchcraft, and of the deep horror with which he regarded those who affected to be sceptical about the reality of that crime, he has left a lasting memorial in a learned and curious volume entitled *Démonomanie*;[1] while the eccentricity of his religious tenets was such, as to incline the candid mind of Grotius to suspect him of a secret leaning to the Jewish faith.[2]

In contemplating the characters of the eminent persons who appeared about this era, nothing is more interesting and instructive, than to remark the astonishing combination, in the same minds, of the highest intellectual endowments, with the most deplorable aberrations of the understanding; and even, in numberless instances, with the most childish superstitions of the multitude. Of this apparent inconsistency, Bodinus does not furnish a solitary example. The same remark may be extended, in a greater or less degree, to most of the other celebrated names hitherto mentioned. Melanchthon, as appears from his letters, was an interpreter of dreams, and a caster of nativities;[3] and Luther not only sanctioned, by his autho-

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men. In 1606, the treatise of *The Republic* was *done into English* by Richard Knolles, who appears to have collated the French and Latin copies so carefully and judiciously, that his version is, in some respects, superior to either of the originals. It is from this version, accordingly, that I have transcribed the passages above quoted; trusting, that it will not be unacceptable to my readers, while looking back to the intellectual attainments of our forefathers, to have an opportunity, at the same time, of marking the progress which had been made in England, more than two centuries ago, in the arts of writing and of translation.

For Dr Johnson's opinion of Knolles's merits as an historian, and as an English writer, see *the Rambler*, No. 123.

[1] *De la Démonomanie des Sorciers.* Par J. Bodin Angevin, à Paris, 1580. This book, which exhibits so melancholy a contrast to the mental powers displayed in the treatise *De la République*, was dedicated by the author to his friend, the President de Thou; and it is somewhat amusing to find, that it exposed Bodin himself to the imputation of being a magician. For this we have the testimony of the illustrious historian just mentioned. (Thuanus, Lib. cxvii. ix.) Nor did it recommend the author to the good opinion of the Catholic church, having been formally condemned and prohibited by the Roman Inquisition. The reflection of the Jesuit Martin del Rio on this occasion is worth transcribing. "*Adeo lubricum et periculosum de his disserere, nisi Deum semper, et catholicam fidem, ecclesiæque Romanæ censuram tanquam cynosuram sequaris.*" *Disquisitionum Magicarum*, Libri Sex. Auctore Martino del Rio, Societatis Jesu Presbytero. Venet. 1640, p. 8.

[2] *Epist. ad Cordesium*, (quoted by Bayle.)

[3] Jortin's *Life of Erasmus*, p. 156.

rity, the popular fables about the sexual and prolific intercourse of Satan with the human race, but seems to have seriously believed that he had himself frequently seen the *arch-enemy* face to face, and held arguments with him on points of theology.[1] Nor was the study of the severer sciences, on all occasions, an effectual remedy against such illusions of the imagination. The *sagacious* Kepler was an astrologer and a visionary; and his friend Tycho Brahe, *the Prince of Astronomers*, kept an idiot in his service, to whose prophecies he listened as revelations from above.[2] During the long night of Gothic barbarism, the intellectual world had again become, like the primitive earth, "without form and void;" the light had already appeared; "and God had seen the light that it was good;" but the time was not yet come to "divide it from the darkness."[3]

In the midst of the disorders, both political and moral, of that unfortunate age, it is pleasing to observe the anticipations of brighter prospects, in the speculations of a few individuals. Bodinus himself is one of the number;[4] and to his name may be added that of his country-

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[1] See Note E.

[2] See *the Life of Tycho Brahe*, by Gassendi.

[3] I have allotted to Bodin a larger space than may seem due to his literary importance; but the truth is, I know of no political writer, of the same date, whose extensive and various and discriminating reading appears to me to have contributed more to facilitate and to guide the researches of his successors; or whose references to ancient learning have been more frequently transcribed without acknowledgment. Of late, his works have fallen into very general neglect; otherwise it is impossible that so many gross mistakes should be current about the scope and spirit of his principles. By many he has been mentioned as a zealot for republican forms of Government (probably for no better reason than that he chose to call his book a Treatise *De Republica*): whereas, in point of fact, he is uniformly a warm and able advocate for monarchy; and, although no friend to tyranny, has, on more than one occasion, carried his monarchical principles to a very blameable excess. (See, in particular, chapter fourth and fifth of the Sixth Book.) On the other hand, Grouvelle, a writer of some note, has classed Bodin with Aristotle, as an advocate for domestic slavery. "The reasonings of both," he says, "are refuted by Montesquieu." (*De l'autorité de Montesquieu dans la Révolution présente.* Paris, 1789.) Whoever has the curiosity to compare Bodin and Montesquieu together, will be satisfied, that, on this point, their sentiments were exactly the same; and that, so far from refuting Bodin, Montesquieu has borrowed from him more than one argument in support of his general conclusion.

The merits of Bodin have been, on the whole, very fairly estimated by Bayle, who pronounces him "one of the ablest men that appeared in France during the sixteenth century." "Si nous voulons disputer à Jean Bodin la qualité d'écrivain éxact et judicieux, laissons lui sans controverse, un grand génie, un vaste savoir, une mémoire et une lecture prodigieuses."

[4] See, in particular, his *Method of Studying History*, chap. vii. entitled, *Confutatio eorum qui quatuor Monarchias Aureaque Secula statuerunt.* In this chapter, after enumerating some of the most important discoveries and inventions of the moderns, he concludes with mentioning the art of printing, of the value of which he seems to have formed a very just estimate. "Una Typographia cum omnibus veterum inventis certare facile potest. Itaque non minus peccant, qui à veteribus aiunt omnia comprehensa, quam qui illos de veteri multarum artium possessione deturbant. Habet Natura scientiarum thesauros innumerabiles, qui nullis ætatibus exhauriri possunt." In the same chapter Bodinus expresses himself thus: "Ætas illa quam *auream* vocant, si ad nostram conferatur, *ferrea* videri possit."

man and predecessor Budæus.[1] But, of all the writers of the sixteenth century, Ludovicus Vives seems to have had the liveliest and the most assured foresight of the new career on which the human mind was about to enter. The following passage from one of his works would have done no discredit to the *Novum Organon*: "The similitude which many have fancied between the superiority of the moderns to the ancients, and the elevation of a dwarf on the back of a giant, is altogether false and puerile. Neither were *they* giants, nor are we dwarfs, but all of us men of the same standard,—and *we* the taller of the two, by adding their height to our own: Provided always, that we do not yield to them in study, attention, vigilance, and love of truth; for, if these qualities be wanting, so far from mounting on the giant's shoulders, we throw away the advantages of our own just stature, by remaining prostrate on the ground."[2]

I pass over, without any particular notice, the names of some French logicians who flourished about this period, because, however celebrated among their contemporaries, they do not seem to form essential links in the History of Science. The bold and persevering spirit with which Ramus disputed, in the university of Paris, the authority of Aristotle, and the persecutions he incurred by this philosophical heresy, entitle him to an honourable distinction from the rest of his brethren. He was certainly a man of uncommon acuteness as well as eloquence, and placed in a very strong light some of the most vulnerable parts of the Aristotelian logic; without, however, exhibiting any marks of that deep sagacity which afterwards enabled Bacon, Descartes, and Locke, to strike at the very roots of the system. His copious and not inelegant style as a writer, recommended his innovations to those who were disgusted with the barbarism of the schools;[3] while his avowed partiality for the reformed

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[1] The works of Budæus were printed at Basle, in four volumes folio, 1557. My acquaintance with them is much too slight to enable me to speak of them from my own judgment. No scholar certainly stood higher in the estimation of his age. "Quo viro," says Ludovicus Vives, "Gallia acutiore ingenio, acriore judicio, exactiore diligentia, majore eruditione nullum unquam produxit; hac vero ætate nec Italia quidem." The praise bestowed on him by other contemporary writers of the highest eminence is equally lavish.

[2] Vives *de Caus. Corrupt. Artium*, Lib. i. Similar ideas occur in the works of Roger Bacon: "Quanto juniores tanto perspicaciores, quia juniores posteriores successione temporum ingrediuntur labores priorum." (*Opus Majus*, Edit. Jebb. p. 9.) Nor were they altogether overlooked by ancient writers. "Veniet tempus, quo ista quæ latent nunc in lucem dies extrahet, et longioris ævi diligentia. Veniet tempus, quo posteri nostri tam aperta nos ignorasse mirabuntur." (Seneca, *Quæst. Nat.* Lib. vii. c. 25.) This language coincides exactly with that of the Chancellor Bacon; but it was reserved for the latter to illustrate the connection between the progress of human *knowledge*, and of human *happiness*; or (to borrow his own phraseology) the connection between the progress of knowledge, and the enlargement of man's *power* over the destiny of his own species. Among other passages to this purpose, See *Nov. Org.* Lib. i. cxxix.

[3] To the accomplishments of Ramus as a writer, a very flattering testimony is given by an eminent English scholar, by no means disposed to overrate his merits as a logician. "Pulsa tandem barbarie, Petrus Ra-

faith (to which he fell a martyr in the massacre of Paris), procured many proselytes to his opinions in all the Protestant countries of Europe. In England his logic had the honour, in an age of comparative light and refinement, to find an expounder and methodiser in the author of Paradise Lost; and in some of our northern universities, where it was very early introduced, it maintained its ground till it was supplanted by the logic of Locke.

It has been justly said of Ramus, that, "although he had genius sufficient to shake the Aristotelian fabric, he was unable to substitute any thing more solid in its place:" but it ought not to be forgotten, that even *this* praise, scanty as it may *now* appear, involves a large tribute to his merits as a philosophical reformer. Before human reason was able to advance, it was necessary that it should first be released from the weight of its fetters. [1]

It is observed, with great truth, by Condorcet, that, in the times of which we are now speaking, "the science of political economy did not exist. Princes estimated not the number of men, but of soldiers in the state;—finance was merely the art of plundering the people, without driving them to the desperation that might end in revolt;—and governments paid no other attention to commerce but that of loading it with taxes, of restricting it by privileges, or of disputing for its monopoly."

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mus politioris literaturæ vir, ausus est Aristotelem acrius ubique et liberius incessere, universamque Peripateticam philosophiam exagitare. Ejus *dialetica* exiguo tempore fuit apud plurimos summo in pretio, maxime eloquentiæ studiosos, idque odio scholasticorum, quorum dictio et *stylus* ingrata fuerant auribus Ciceronianis." *Logicæ Artis Compendium,* Auctore R. Sanderson, Episc. Lincoln, pp. 250, 251. Edit. Decima. Oxon. The first edition was printed in 1618.

[1] Dr Barrow, in one of his mathematical lectures, speaks of Ramus in terms far too contemptuous. "Homo, ne quid gravius dicam, *argutulus et dicaculus.*"—"Sane vix indignationi meæ tempero, quin illum accipiam pro suo merito, regeramque validius in ejus caput, quæ contra veteres jactat convicia." Had Barrow confined this censure to the weak and arrogant attacks made by Ramus upon Euclid (particularly upon Euclid's definition of Proportion), it would not have been more than Ramus deserved; but it is evident he meant to extend it also to the more powerful attacks of the same reformer upon the logic of Aristotle. Of these there are many which may be read with profit even in the present times. I select one passage as a specimen, recommending it strongly to the consideration of those logicians who have lately stood forward as advocates for Aristotle's *abecedarian* demonstrations of the syllogistic rules. "In Aristotelis arte, unius præcepti unicum exemplum est, ac sæpissime nullum: Sed unico et singulari exemplo non potest artifex effici; pluribus opus est et dissimilibus. Et quidem, ut Aristotelis exempla tantummodo non falsa sint, qualia tamen sunt? Omne *b* est *a*: omne *c* est *b*: ergo omne *c* est *a*. Exemplum Aristotelis est puero à grammaticis et oratoribus venienti, et istam mutorum Mathematicorum linguam ignoranti, novum et durum: et in totis Analyticis istâ non Atticâ, non Ionicâ, non Doricâ, non Æolicâ, non communi, sed geometricâ linguâ usus est Aristoteles, odiosâ pueris, ignotâ populo, â communi sensu remotâ, â rhetoricæ usu et ab humanitatis usu alienissimâ." (P. Rami *pro Philosophica Parisiensis Academiæ Disciplina Oratio,* 1550.) If these strictures should be thought too loose and declamatory, the reader may consult the fourth chapter *(De Conversionibus)* of the seventh book of Ramus's *Dialectics,* where the same charge is urged, in my opinion, with irresistible force of argument.

The internal disorders then agitating the whole of Christendom, were still less favourable to the growth of this science, considered as a branch of speculative study. Religious controversies everywhere divided the opinions of the multitude;—involving those collateral discussions concerning the liberty of conscience, and the relative claims of sovereigns and subjects, which, by threatening to resolve society into its first elements, present to restless and aspiring spirits the most inviting of all fields for enterprise and ambition. Amidst the shock of such discussions, the calm inquiries which meditate in silence the slow and gradual amelioration of the social order, were not likely to possess strong attractions, even to men of the most sanguine benevolence; and, accordingly, the political speculations of this period turn almost entirely on the comparative advantages and disadvantages of different forms of government; or on the still more alarming questions concerning the limits of allegiance and the right of resistance.

The dialogue of our illustrious countryman Buchanan, *De Jure Regni apud Scotos*, though occasionally disfigured by the keen and indignant temper of the writer, and by a predilection (pardonable in a scholar warm from the schools of ancient Greece and Rome) for forms of policy unsuitable to the circumstances of modern Europe, bears, nevertheless, in its general spirit, a closer resemblance to the political philosophy of the eighteenth century, than any composition which had previously appeared. The ethical paradoxes afterwards inculcated by Hobbes as the ground-work of his slavish theory of government, are anticipated and refuted; and a powerful argument is urged against that doctrine of Utility which has attracted so much notice in our times. The political reflections, too, incidentally introduced by the same author in his History of Scotland, bear marks of a mind worthy of a better age than fell to his lot. Of this kind are the remarks with which he closes his narrative of the wanton cruelties exercised in punishing the murderers of James the First. In reading them, one would almost imagine, that one is listening to the voice of Beccaria or of Montesquieu. "After this manner," says the historian, "was the cruel death of James still more cruelly avenged. For punishments so far exceeding the measure of humanity, have less effect in deterring the multitude from crimes, than in rousing them to greater efforts, both as actors and as sufferers. Nor do they tend so much to intimidate by their severity, as by their frequency to diminish the terrors of the spectators. The evil is more peculiarly great, when the mind of the criminal is hardened against the sense of pain; for in the judgment of the unthinking vulgar, a stubborn confidence generally obtains the praise of heroic constancy."

After the publication of this great work, the name of Scotland, so early distinguished

over Europe by the learning and by the *fervid genius*[1] of her sons, disappears for more than a century and a half from the History of Letters.—But from this subject, so pregnant with melancholy and humiliating recollections, our attention is forcibly drawn to a mighty and auspicious light which, in a more fortunate part of the island, was already beginning to rise on the philosophical world.[2]

# CHAPTER II.

## FROM THE PUBLICATION OF BACON'S PHILOSOPHICAL WORKS, TILL THAT OF THE ESSAY ON HUMAN UNDERSTANDING.

### SECTION I.

### *Progress of Philosophy in England during this period.*

### BACON.[3]

THE state of science towards the close of the sixteenth century, presented a field of observation singularly calculated to attract the curiosity, and to awaken the genius of Bacon; nor was it the least of his personal advantages, that, as the son of one of Queen Elizabeth's ministers, he had a ready access, wherever he went, to the most enlightened society in Europe. While yet only in the seventeenth year of his age, he was removed by his father from Cambridge to Paris, where it is not to be doubted, that the novelty of the literary scene must have largely contributed to cherish the natural liberality and independence of his

[1] Præfervidum Scotorum ingenium.

[2] That, at the end of the sixteenth century, the Scotish nation were advancing not less rapidly than their neighbours, in every species of mental cultivation, is sufficiently attested by their literary remains, both in the Latin language, and in their own vernacular tongue. A remarkable testimony to the same purpose occurs in the dialogue above quoted; the author of which had spent the best years of his life in the most polished society of the Continent. "As often," says Buchanan, "as I turn my eyes to the niceness and elegance of our own times, the ancient manners of our forefathers appear sober and venerable, but withal rough and horrid."—"Quoties oculos ad nostri temporis munditias et elegantiam refero, antiquitas illa sancta et sobria, sed *horrida* tamen, et nondum *satis expolita*, fuisse videtur." (*De Jure Regni apud Scotos.*) One would think, that he conceived the taste of his countrymen to have then arrived at the *ne plus ultra* of national refinement,

*Aurea* nunc, olim sylvestribus *horrida* dumis.

[3] Born 1561, died 1626.

mind. Sir Joshua Reynolds has remarked, in one of his academical Discourses, that "every seminary of learning is surrounded with an atmosphere of floating knowledge, where every mind may imbibe somewhat congenial to its own original conceptions."[1] He might have added, with still greater truth, that it is an atmosphere, of which it is more peculiarly salutary for those who have been elsewhere reared to breathe the air. The remark is applicable to higher pursuits than were in the contemplation of this philosophical artist; and it suggests a hint of no inconsiderable value for the education of youth.

The merits of Bacon, as the father of Experimental Philosophy, are so universally acknowledged, that it would be superfluous to touch upon them here. The lights which he has struck out in various branches of the Philosophy of Mind, have been much less attended to; although the whole scope and tenor of his speculations shew, that to *this* study his genius was far more strongly and happily turned, than to that of the Material World. It was not, as some seem to have imagined, by sagacious anticipations of particular discoveries afterwards to be made in physics, that his writings have had so powerful an influence in accelerating the advancement of that science. In the extent and accuracy of his *physical* knowledge, he was far inferior to many of his predecessors; but he surpassed them all in his knowledge of the laws, the resources, and the limits of the human understanding. The sanguine expectations with which he looked forwards to the future, were founded solely on his confidence in the untried *capacities of the mind*; and on a conviction of the possibility of invigorating and guiding, by means of logical rules, those faculties which, in all our researches after truth, are the organs or instruments to be employed. "Such rules," as he himself has observed, "do in some sort equal men's wits, and leave no great advantage or pre-eminence to the perfect and excellent motions of the spirit. To draw a straight line, or to describe a circle, by aim of hand only, there must be a great difference between an unsteady and unpractised hand, and a steady and practised; but to do it by rule or compass it is much alike."

Nor is it merely as a logician that Bacon is entitled to notice on the present occasion. It would be difficult to name another writer prior to Locke, whose works are enriched with so many just observations on the intellectual phenomena. Among these, the most valuable relate to the laws of Memory, and of Imagination; the latter of which subjects he seems to have studied with peculiar care. In one short but beautiful paragraph concerning *Poetry* (under which title may be comprehended all the various creations of this faculty), he has exhausted every thing that philosophy and good sense have yet had to offer, on what has been since called the *Beau Ideal*; a topic, which has furnished occasion to so many

[1] Discourse delivered at the opening of the Royal Academy, January 2, 1769.

over-refinements among the French critics, and to so much extravagance and mysticism in the *cloud-capt* metaphysics of the new German school.[1] In considering imagination as connected with the nervous system, more particularly as connected with that species of sympathy to which medical writers have given the name of *imitation*, he has suggested some very important hints, which none of his successors have hitherto prosecuted; and has, at the same time, left an example of cautious inquiry, worthy to be studied by all who may attempt to investigate the laws regulating the union between Mind and Body.[2] His illustration of the different classes of prejudices incident to human nature, is, in point of practical utility, at least equal to any thing on that head to be found in Locke; of whom it is impossible to forbear remarking, as a circumstance not easily explicable, that he should have resumed this important discussion, without once mentioning the name of his great predecessor. The chief improvement made by Locke, in the farther prosecution of the argument, is the application of Hobbes's theory of association, to explain in what manner these prejudices are originally generated.

In Bacon's scattered hints on topics connected with the Philosophy of the Mind, strictly

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1 "Cum mundus sensibilis sit anima rationali dignitate inferior, videtur *Poësis* hæc humanæ naturæ largiri quæ historia denegat; atque animo umbris rerum utcunque satisfacere, cum solida haberi non possint. Si quis enim rem acutius introspiciat, firmum ex *Poësi* sumitur argumentum, magnitudinem rerum magis illustrem, ordinem magis perfectum, et varietatem magis pulchram, animæ humanæ complacere, quam in natura ipsa, post lapsum, reperiri ullo modo possit. Quapropter, cum res gestæ et eventus, qui veræ historiæ subjiciuntur, non sint ejus amplitudinis, in qua anima humana sibi satisfaciat, præsto est *Poësis*, quæ facta magis heroica confingat. Cum historia vera successus rerum, minime pro meritis virtutum et scelerum narret, corrigit eam *Poësis*, et exitus, et fortunas, secundum merita, et ex lege Nemeseos, exhibet. Cum historia vera obvia rerum satietate et similitudine, animæ humanæ fastidio sit, reficit eam Poësis, inexpectata, et varia, et vicissitudinum plena canens. Adeo ut *Poësis* ista non solum ad delectationem, sed ad animi magnitudinem, et ad mores conferat." (*De Aug. Scient.* Lib. ii. cap. xiii.)

2 To this branch of the philosophy of mind, Bacon gives the title of *Doctrina de fœdere, sive de communi vinculo animæ et corporis*. (*De Aug. Scient.* Lib. iv. cap. i.) Under this article, he mentions, among other *desiderata*, an inquiry (which he recommends to physicians) concerning the influence of imagination over the body. His own words are very remarkable; more particularly, the clause in which he remarks the effect of fixing and concentrating the attention, in giving to ideal objects the power of realities over the belief. "Ad aliud quippiam, quod huc pertinet, parce admodum, nec pro rei subtilitate, vel utilitate, inquisitum est; quatenus scilicet *ipsa imaginatio animæ vel cogitatio perquam fixa, et veluti in fidem quandam exaltata*, valeat ad immutandum corpus imaginantis." (Ibid.) He suggests also, as a curious problem, to ascertain how far it is possible to fortify and exalt the imagination; and by what means this may most effectually be done. The class of facts here alluded to, are manifestly of the same description with those to which the attention of philosophers has been lately called by the pretensions of Mesmer and of Perkins: "Atque huic conjuncta est disquisitio, quomodo imaginatio intendi et fortificari possit? Quippe, si imaginatio fortis tantarum sit virium, operæ pretium fuerit nosse, quibus modis eam exaltari, et se ipsa majorem fieri detur? Atque hic oblique, nec minus periculose se insinuat palliatio quædam et defensio maximæ partis *Magicæ Ceremonialis*." &c. &c. *De Aug. Scient.* Lib. iv. cap. iii.

so called, nothing is more remarkable than the precise and just ideas they display of the proper aim of this science. He had manifestly reflected much and successfully on the operations of his own understanding, and had studied with uncommon sagacity the intellectual characters of others. Of his reflections and observations on both subjects, he has recorded many important results; and has in general stated them without the slightest reference to any physiological theory concerning their causes, or to any analogical explanations founded on the caprices of metaphorical language. If, on some occasions, he assumes the existence of *animal spirits*, as the medium of communication between Soul and Body, it must be remembered, that this was *then* the universal belief of the learned; and that it was at a much later period not less confidently avowed by Locke. Nor ought it to be overlooked (I mention it to the credit of *both* authors), that in such instances the *fact* is commonly so stated, as to render it easy for the reader to detach it from the *theory*. As to the scholastic questions concerning the nature and essence of mind,—whether it be extended or unextended? whether it have any relation to space or to time? or whether (as was contended by others) it exist in *every ubi*, but in *no place*?—Bacon has uniformly passed them over with silent contempt; and has probably contributed not less effectually to bring them into general discredit, by this indirect intimation of his own opinion, than if he had descended to the ungrateful task of exposing their absurdity.[1]

While Bacon, however, so cautiously avoids these unprofitable discussions about the nature of Mind, he decidedly states his conviction, that the *faculties* of Man differ not merely in degree, but in kind, from the instincts of the brutes. "I do not, therefore," he observes on one occasion, "approve of that confused and promiscuous method in which philosophers are accustomed to treat of pneumatology; as if the human

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[1] Notwithstanding the extravagance of Spinoza's own philosophical creed, he is one of the very few among Bacon's successors, who seem to have been fully aware of the justness, importance, and originality of the method pointed out in the *Novum Organon* for the study of the Mind. "Ad hæc intelligenda, non est opus *naturam mentis* cognoscere, sed sufficit, mentis sive *perceptionum* historiolam concinnare modo illo quo VERULAMIUS docet." *Spin. Epist.* 42.

In order to comprehend the whole merit of this remark, it is necessary to know that, according to the Cartesian phraseology, which is here adopted by Spinoza, the word *perception* is a general term, equally applicable to all the intellectual operations. The words of Descartes himself are these: "Omnes modi cogitandi, quos in nobis experimur, ad duos generales referri possunt: quorum unus est, *perceptio*, sive operatio intellectus; alius verò, *volitio*, sive operatio voluntatis. *Nam sentire, imaginari, et pure intelligere, sunt tantum diversi modi percipiendi;* ut et cupere, aversari, affirmare, negare, dubitare, sunt diversi modi volendi." *Princ. Phil.* Pars I. § 32.

Soul ranked above those of brutes, merely like the sun above the stars, or like gold above other metals."

Among the various topics started by Bacon for the consideration of future logicians, he did not overlook (what may be justly regarded, in a practical view, as the most interesting of all logical problems) the question concerning the mutual influence of Thought and of Language on each other. "Men believe," says he, "that their reason governs their words; but, it often happens, that words have power enough to *re-act* upon reason." This aphorism may be considered as the text of by far the most valuable part of Locke's Essay,—*that* which relates to the imperfections and abuse of words; but it was not till within the last twenty years, that its depth and importance were perceived in all their extent. I need scarcely say, that I allude to the excellent Memoirs of M. Prevost and of M. Degerando, on "Signs considered in their connection with the Intellectual Operations." The anticipations formed by Bacon, of that branch of modern logic which relates to *Universal Grammar*, do no less honour to his sagacity. "Grammar," he observes, "is of two kinds, the one literary, the other philosophical. The former has for its object to trace the analogies running through the structure of a particular tongue, so as to facilitate its acquisition to a foreigner, or to enable him to speak it with correctness and purity. The latter directs the attention, *not* to the analogies which words bear to words, but to the analogies which words bear to things;"[1] or, as he afterwards explains himself more clearly, "to language considered as the sensible portraiture or image of the mental processes." In farther illustration of these hints, he takes notice of the lights which the different genius of different languages reflect on the characters and habits of those by whom they were respectively spoken. "Thus," says he, "it is easy to perceive, that the Greeks were addicted to the culture of the arts, the Romans engrossed with the conduct of affairs; inasmuch, as the technical distinctions introduced in the progress of refinement require the aid of compounded words; while the real business of life stands in no need of so artificial a phraseology."[2] Ideas of this sort have, in the course of a very few years, already become common, and almost tritical; but how different was the case two centuries ago!

With these sound and enlarged views concerning the Philosophy of the Mind, it will not appear surprising to those who have attended to the slow and irregular advances of human reason, that Bacon should occasionally blend incidental remarks, savouring of the ha-

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[1] *De Aug. Scient.* Lib. vi. cap. i.

[2] Ibid.

bits of thinking prevalent in his time. A curious example of this occurs in the same chapter which contains his excellent definition or description of universal grammar. "This too," he observes, "is worthy of notice, that the ancient languages were full of declensions, of cases, of conjugations, of tenses, and of other similar inflections; while the modern, almost entirely destitute of these, indolently accomplish the same purpose by the help of prepositions, and of auxiliary verbs. Whence," he continues, "may be inferred (however we may flatter ourselves with the idea of our own superiority), that the human intellect was much more acute and subtile in ancient, than it now is in modern times."[1] How very unlike is this last reflection to the usual strain of Bacon's writings! It seems, indeed, much more congenial to the philosophy of Mr Harris and of Lord Monboddo; and it has accordingly been sanctioned with the approbation of both these learned authors. If my memory does not deceive me, it is the only passage in Bacon's works, which Lord Monboddo has anywhere condescended to quote.

These observations afford me a convenient opportunity for remarking the progress and diffusion of *the philosophical spirit*, since the beginning of the seventeenth century. In the short passage just cited from Bacon, there are involved no less than two capital errors, which are now almost universally ranked, by men of education, among the grossest prejudices of the multitude. The one, that the declensions and conjugations of the ancient languages, and the modern substitution in their place, of prepositions and auxiliary verbs, are, both of them, the deliberate and systematical contrivances of speculative grammarians; the other (still less analogous to Bacon's general style of reasoning), that the faculties of man have declined, as the world has grown older. Both of these errors may be now said to have disappeared entirely. The latter, more particularly, must, to the rising generation, seem so absurd, that it almost requires an apology to have mentioned it. That the capacities of the human mind have been in all ages the same; and that the diversity of phenomena exhibited by our species, is the result merely of the different circumstances in which men are placed, has been long received as an incontrovertible logical maxim; or rather, such is the influence of early instruction, that we are apt to regard it as one of the most obvious suggestions of common sense. And yet, till about the time of Montesquieu, it was by no means so generally recognized by the learned, as to have a sensible influence on the fashionable tone of thinking over Europe. The application of this fundamental and leading idea to the natural or *theoretical history* of society in all its vari-

[1] *De Aug. Scient.* Lib. vi. cap. i.

ous aspects;—to the history of languages, of the arts, of the sciences, of laws, of government, of manners, and of religion,—is the peculiar glory of the latter half of the eighteenth century; and forms a characteristical feature in its philosophy, which even the imagination of Bacon was unable to foresee.

It would be endless to particularize the original suggestions thrown out by Bacon on topics connected with the science of Mind. The few passages of this sort already quoted, are produced merely as a specimen of the rest. They are by no means selected as the most important in his writings; but, as they happened to be those which had left the strongest impression on my memory, I thought them as likely as any other, to invite the curiosity of my readers to a careful examination of the rich mine from which they are extracted.

The Ethical disquisitions of Bacon are almost entirely of a practical nature. Of the two theoretical questions so much agitated, in both parts of this Island, during the eighteenth century, concerning the *principle* and the *object* of moral approbation, he has said nothing; but he has opened some new and interesting views with respect to the influence of *custom* and the formation of *habits*;—a most important article of moral philosophy, on which he has enlarged more ably and more usefully than any writer since Aristotle.[1] Under the same head of *Ethics* may be mentioned the small volume to which he has given the title of *Essays*; the best known and the most popular of all his works. It is also one of those where the superiority of his genius appears to the greatest advantage; the novelty and depth of his reflections often receiving a strong relief from the triteness of his subject. It may be read from beginning to end in a few hours,—and yet, after the twentieth perusal, one seldom fails to remark in it something overlooked before. This, indeed, is a characteristic of all Bacon's writings, and is only to be accounted for by the inexhaustible aliment they furnish to our own thoughts, and the sympathetic activity they impart to our torpid faculties.

The suggestions of Bacon for the improvement of Political Philosophy, exhibit as strong a contrast to the narrow systems of contemporary statesmen, as the Inductive Logic to that of the Schools. How profound and comprehensive are the views opened in the following passages, when compared with the scope of the celebrated treatise *De Jure Belli et Pacis*; a work which was first published about a year before Bacon's death, and which continued, for a hundred and fifty years afterwards, to be regarded in all the Protestant universities of Europe as an inexhaustible treasure of moral and jurisprudential wisdom!

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[1] *De Aug. Scient.* Lib. vii. cap. iii.

"The ultimate object which legislators ought to have in view, and to which all their enactments and sanctions ought to be subservient, is, *that the citizens may live happily.* For this purpose, it is necessary that they should receive a religious and pious education; that they should be trained to good morals; that they should be secured from foreign enemies by proper military arrangements; that they should be guarded by an effectual police against seditions and private injuries; that they should be loyal to government, and obedient to magistrates; and finally, that they should abound in wealth, and in other national resources."[1]—"The science of such matters certainly belongs more particularly to the province of men who, by habits of public business, have been led to take a comprehensive survey of the social order; of the interests of the community at large; of the rules of natural equity; of the manners of nations; of the different forms of government; and who are thus prepared to reason concerning the wisdom of laws, both from considerations of justice and of policy. The great desideratum, accordingly, is, by investigating the principles of *natural justice*, and those of *political expediency*, to exhibit a theoretical model of legislation, which, while it serves as a standard for estimating the comparative excellence of municipal codes, may suggest hints for their correction and improvement, to such as have at heart the welfare of mankind."[2]

How precise the notion was that Bacon had formed of a philosophical system of jurisprudence (with which as a standard the municipal laws of different nations might be compared), appears from a remarkable expression, in which he mentions it as the proper business of those who might attempt to carry his plan into execution, to investigate those "LEGES LEGUM, ex quibus informatio peti possit, quid in singulis legibus bene aut perperam positum aut constitutum sit."[3] I do not know if, in Bacon's prophetic anticipa-

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[1] *Exemplum Tractatus de Fontibus Juris*, Aphor. 5. This enumeration of the different objects of law approaches very nearly to Mr Smith's ideas on the same subject, as expressed by himself in the concluding sentence of his *Theory of Moral Sentiments*. "In another Discourse, I shall endeavour to give an account of the general principles of law and government, and of the different revolutions they have undergone in the different ages and periods of society; not only in what concerns justice, but in what concerns police, revenue, and arms, and whatever else is the object of law."

[2] *De Aug. Scient.* Lib. viii. cap. iii.

[3] *De Fontibus Juris*, Aphor. 6.

From the preface to a small tract of Bacon's, entitled *The Elements of the Common Laws of England*, (written while he was Solicitor-General to Queen Elizabeth), we learn, that the phrase *legum leges* had been previously used by some "great Civilian." To what *civilian* Bacon here alludes, I know not; but, whoever he was, I doubt much if he annexed to it the comprehensive and philosophical meaning, so precisely explained in the above definition. Bacon himself, when he wrote his Tract on the Common Laws, does not seem to have yet risen to this vantage-ground of Universal Jurisprudence. His great object (he tells us) was "to collect the rules and grounds dispersed throughout the body of the same laws,

tions of the future progress of physics, there be anything more characteristical, both of the grandeur and of the justness of his conceptions, than this short definition; more particularly, when we consider how widely Grotius, in a work professedly devoted to this very inquiry, was soon after to wander from the right path, in consequence of his vague and wavering idea of the aim of his researches.

The sagacity, however, displayed in these, and various other passages of a similar import, can by no means be duly appreciated, without attending, at the same time, to the cautious and temperate maxims so frequently inculcated by the author, on the subject of political innovation. "A stubborn retention of customs is a turbulent thing, not less than the introduction of new."—"Time is the greatest innovator; shall we then not imitate time, which innovates so silently as to mock the sense?" Nearly connected with these aphorisms, are the profound reflections in the first book *De Augmentis Scientiarum*, on the necessity of accommodating every new institution to the character and circumstances of the people for whom it is intended; and on the peculiar danger which literary men run of overlooking this consideration, from the familiar acquaintance they acquire, in the course of their early studies, with the ideas and sentiments of the ancient classics.

The remark of Bacon on the systematical policy of Henry VII. was manifestly suggested by the same train of thinking. "His laws (whoso marks them well) were deep and not vulgar; not made on the spur of a particular occasion for the present, but out of providence for the future; to make the estate of his people still more and more happy, after the manner of the legislators in ancient and heroic times." How far this noble eulogy was merited, either by the legislators of antiquity, or by the modern Prince on whom Bacon has bestowed it, is a question of little moment. I quote it merely on account of the important philosophical distinction which it indirectly marks, between "deep and vulgar laws;" the former invariably aiming to accomplish their end, not by giving any sudden shock to the feelings and interests of the existing generation, but by allowing to natural causes time and opportunity to operate; and by removing those artificial ob-

in order to see more profoundly into the reason of such judgments and ruled cases, and thereby to make more use of them for the decision of other cases more doubtful; so that the uncertainty of law, which is the principal and most just challenge that is made to the laws of our nation at this time, will, by this new strength laid to the foundation, be somewhat the more settled and corrected." In this passage, no reference whatever is made to the *Universal Justice* spoken of in the aphorisms *de Fontibus Juris*; but merely to the leading and governing rules which give to a municipal system whatever it possesses of analogy and consistency. To these rules Bacon gives the title of *leges legum;* but the meaning of the phrase, on this occasion, differs from that in which he afterwards employed it, not less widely than the rules of Latin or of Greek syntax differ from the principles of universal grammar.

stacles which check the progressive tendencies of society. It is probable, that, on this occasion, Bacon had an eye more particularly to the memorable *statute of alienation;* to the effects of which (whatever were the motives of its author) the above description certainly applies in an eminent degree.

After all, however, it must be acknowledged, that it is rather in his general views and maxims, than in the details of his political theories, that Bacon's sagacity appears to advantage. His notions with respect to commercial policy seem to have been more peculiarly erroneous; originating in an overweening opinion of the efficacy of law, in matters where natural causes ought to be allowed a free operation. It is observed by Mr Hume, that the statutes of Henry VII. relating to the police of his kingdom, are generally contrived with more judgment than his commercial regulations. The same writer adds, that "the more simple ideas of order and equity are sufficient to guide a legislator in everything that regards the internal administration of justice; but that the principles of commerce are much more complicated, and require long experience and deep reflection to be well understood in any state. The real consequence is *there* often contrary to first appearances. No wonder, that, during the reign of Henry VII. these matters were frequently mistaken; and it may safely be affirmed, that, even in the age of Lord Bacon, very imperfect and erroneous ideas were formed on that subject."

The instances mentioned by Hume in confirmation of these general remarks, are peculiarly gratifying to those who have a pleasure in tracing the slow but certain progress of reason and liberality. "During the reign," says he, "of Henry VII. it was prohibited to export horses, as if that exportation did not encourage the breed, and make them more plentiful in the kingdom. Prices were also affixed to woollen cloths, to caps and hats, and the wages of labourers were regulated by law. IT IS EVIDENT, *that these matters ought always to be left free, and be entrusted to the common course of business and commerce.*"—"For a like reason," the historian continues, "the law enacted against inclosures, and for the keeping up of farm-houses, scarcely deserves the praises bestowed on it by Lord Bacon. If husbandmen understand agriculture, and have a ready vent for their commodities, we need not dread a diminution of the people employed in the country. During a century and a half after this period, there was a frequent renewal of laws and edicts against depopulation; whence we may infer, that none of them were ever executed. *The natural course of improvement at last provided a remedy.*"

These acute and decisive strictures on the impolicy of some laws highly applauded by Bacon, while they strongly illustrate the narrow and mistaken views in political economy entertained by the wisest statesmen and philosophers two centuries ago, afford, at the same

time, a proof of the general diffusion which has since taken place among the people of Great Britain, of juster and more enlightened opinions on this important branch of legislation. Wherever such doctrines find their way into the page of history, it may be safely inferred, that the public mind is not indisposed to give them a welcome reception.

The ideas of Bacon concerning the education of youth, were such as might be expected from a philosophical statesman. On the conduct of education in general, with a view to the developement and improvement of the intellectual character, he has suggested various useful hints in different parts of his works; but what I wish chiefly to remark at present is, the paramount importance which he has attached to the education of the people,—comparing (as he has repeatedly done) the effects of early culture on the understanding and the heart, to the abundant harvest which rewards the diligent husbandman for the toils of the spring. To this analogy he seems to have been particularly anxious to attract the attention of his readers, by bestowing on education the title of *the Georgics of the Mind*; identifying, by a happy and impressive metaphor, the two proudest functions entrusted to the legislator,—the encouragement of agricultural industry, and the care of national instruction. In both instances, the legislator exerts a power which is literally *productive* or *creative*; compelling, in the one case, the unprofitable desert to pour forth its latent riches; and in the other, vivifying the dormant seeds of genius and virtue, and redeeming from the neglected wastes of human intellect, a new and unexpected accession to the common inheritance of mankind.

When from such speculations as these we descend to the treatise *De Jure Belli et Pacis*, the contrast is mortifying indeed. And yet, so much better suited were the talents and accomplishments of Grotius to the taste, not only of his contemporaries, but of their remote descendants, that, while the merits of Bacon failed, for a century and a half, to command the general admiration of Europe,[1] Grotius continued, even in our British universities, the acknowledged Oracle of Jurisprudence and of Ethics, till long after the death of Montesquieu. Nor was Bacon himself unapprised of the slow growth of his posthumous fame. No writer seems ever to have felt more deeply, that he properly belonged to a later and more enlightened age;—a sentiment which he has pathetically expressed in that clause

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[1] "La célébrité en France des écrits du Chancelier Bacon n'a guere pour date que celle de l'Encyclopédie." (*Histoire des Mathématiques par Montucla*, Preface, p. ix.) It is an extraordinary circumstance, that Bayle, who has so often wasted his erudition and acuteness on the most insignificant characters, and to whom Le Clerc has very justly ascribed the merit of *une exactitude étonnante dans des choses de néant*, should have devoted to Bacon only twelve lines of his Dictionary.

of his testament, where he "bequeaths his name to posterity, after some generations shall be past." [1]

Unbounded, however, as the reputation of Grotius was on the Continent, even before his own death, it was not till many years after the publication of the treatise *De Jure Belli et Pacis*, that the science of natural jurisprudence became, in this Island, an object of much attention, even to the learned. In order, therefore, to give to the sequel of this section some degree of continuity, I shall reserve my observations on Grotius and his successors, till I shall have finished all that I think it necessary to mention further, with respect to the literature of our own country, prior to the appearance of Mr Locke's Essay.

The rapid advancement of intellectual cultivation in England, between the years 1588 and 1640 (a period of almost uninterrupted peace), has been remarked by Mr Fox. "The general improvement," he observes, "in all arts of civil life, and above all, the astonishing progress of literature, are the most striking among the general features of that period; and are in themselves causes sufficient to produce effects of the utmost importance. A country whose language was enriched by the works of Hooker, Raleigh, and Bacon, could not but experience a sensible change in its manners, and in its style of thinking; and even to speak the same language in which Spencer and Shakespeare had written, seemed a sufficient plea to rescue the Commons of England from the appellation of *Brutes*, with which Henry the Eighth had addressed them."—The remark is equally just and refined. It is by the mediation of an improving language, that the progress of the mind is chiefly continued from one generation to another; and that the acquirements of the enlightened few are insensibly imparted to the many. Whatever tends to diminish the ambiguities of speech, or to fix, with more logical precision, the import of general terms;—above all, whatever tends to embody, in popular forms of expression, the ideas and feelings of the wise and good, augments the natural powers of the human understanding, and enables the succeeding race to start from a higher ground than was occupied by their fathers. The remark applies with peculiar force to the study of the Mind itself; a study, where the chief source of error is the imperfection of words; and where every improvement on this great instrument of thought may be justly regarded in the light of a discovery. [2]

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[1] See Note F.

[2] It is not so foreign as may at first be supposed to the object of this Discourse, to take notice here of the extraordinary demand for books on *Agriculture* under the government of James I. The fact is thus very

In the foregoing list of illustrious names, Mr Fox has, with much propriety, connected those of Bacon and Raleigh; two men, who, notwithstanding the diversity of their professional pursuits, and the strong constrast of their characters, exhibit, nevertheless, in their capacity of authors, some striking features of resemblance. Both of them owed to the force of their own minds, their emancipation from the fetters of the schools; both were eminently distinguished above their contemporaries, by the originality and enlargement of their philosophical views; and both divide, with the venerable Hooker, the glory of exemplifying to their yet unpolished countrymen, the richness, variety, and grace, which might be lent to the English idiom, by the hand of a master.[1]

It is not improbable that Mr Fox might have included the name of Hobbes in the same enumeration, had he not been prevented by an aversion to his slavish principles of government, and by his general disrelish for metaphysical theories. As a writer, Hobbes unquestionably ranks high among the older English classics; and is so peculiarly distinguished by the simplicity and ease of his manner, that one would naturally have expected from Mr Fox's characteristical taste, that he would have relished *his* style still more than that of Bacon[2] or of Raleigh.—It is with the *philosophical* merits, however, of Hobbes, that we

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strongly stated by Dr Johnson, in his introduction to the Harleian Miscellany. "It deserves to be remarked, because it is not generally known, that the treatises on husbandry and agriculture, which were published during the reign of King James, are so numerous, that it can scarcely be imagined by whom they were written, or to whom they were sold." Nothing can illustrate more strongly the effects of a pacific system of policy, in encouraging a general taste for reading, as well as an active spirit of national improvement. At all times, and in every country, the extensive sale of *books on agriculture*, may be regarded as one of the most pleasing symptoms of mental cultivation in the great body of a people.

[1] To prevent being misunderstood, it is necessary for me to add, that I do not speak of the *general style* of these old authors; but only of detached passages, which may be selected from all of them, as earnests or first fruits of a new and brighter era in English literature. It may be safely affirmed, that in *their* works, and in the prose compositions of Milton, are to be found some of the finest sentences of which our language has yet to boast. To propose them *now* as models for imitation, would be quite absurd. Dr Lowth certainly went much too far when he said, "That in *correctness*, *propriety*, and *purity* of English style, Hooker hath hardly been surpassed, or even equalled, by any of his successors." *Preface to Lowth's English Grammar.*

[2] According to Dr Burnet (no contemptible judge of style), Bacon was "the first that *writ* our language correctly." The same learned prelate pronounces Bacon to be "*still* our best author;" and *this*, at a time, when the works of Sprat, and many of the prose compositions of Cowley and of Dryden, were already in the hands of the public. It is difficult to conceive on what grounds Burnet proceeded, in hazarding so extraordinary an opinion. See the preface to Burnet's translation of More's *Utopia*.

It is still more difficult, on the other hand, to account for the following very bold decision of Mr Hume. I transcribe it from an essay first published in 1742; but the same passage is to be found in the last edition of his works, corrected by himself. "The first polite prose we have, was *writ* by a man (Dr Swift) who is

are alone concerned at present ; and, in this point of view, what a space is filled in the subsequent history of our domestic literature, by his own works, and by those of his innumerable opponents ! Little else, indeed, but the systems which he published, and the controversies which they provoked, occurs, during the interval between Bacon and Locke, to mark the progress of English Philosophy, either in the study of the Mind, or in the kindred researches of Ethical and Political Science.

Of the few and comparatively trifling exceptions to this remark, furnished by the metaphysical tracts of Glanville, of Henry More, and of John Smith, I must delay taking notice, till some account shall be given of the Cartesian philosophy ; to which their most interesting discussions have a constant reference, either in the way of comment or refutation.

## HOBBES. [1]

"The philosopher of Malmesbury," says Dr Warburton, "was the terror of the last age, as Tindall and Collins are of this. The press sweat with controversy ; and every young churchman militant, would try his arms in thundering on Hobbes's steel cap." [2] Nor was the opposition to Hobbes confined to the clerical order, or to the controversialists of his own times. The most eminent moralists and politicians of the eighteenth century may be ranked in the number of his antagonists, and even at the present moment, scarcely does there appear a new publication on Ethics or Jurisprudence, where a refutation of Hobbism is not to be found.

The period when Hobbes began his literary career, as well as the principal incidents of his life, were, in a singular degree, favourable to a mind like his ; impatient of the yoke of authority, and ambitious to attract attention, if not by solid and useful discoveries, at least by an ingenious defence of paradoxical tenets. After a residence of five years at Oxford,

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still alive. As to Sprat, Locke, and even Temple, they knew too little of the rules of art to be esteemed elegant writers. The prose of Bacon, Harrington, and Milton, is altogether stiff and pedantic ; though their sense be excellent."

How insignificant are the petty grammatical improvements proposed by Swift, when compared with the inexhaustible riches imparted to the English tongue by the writers of the seventeenth century ; and how inferior, in all the higher qualities and graces of style, are his prose compositions, to those of his immediate predecessors, Dryden, Pope, and Addison !

[1] Born 1588, died 1679.

[2] *Divine Legation*, Pref. to Vol. II. p. 9.

and a very extensive tour through France and Italy, he had the good fortune, upon his return to England, to be admitted into the intimacy and confidence of Lord Bacon; a circumstance which, we may presume, contributed not a little to encourage that bold spirit of inquiry, and that aversion to scholastic learning, which characterize his writings. Happy, if he had, at the same time, imbibed some portion of that love of truth and zeal for the advancement of knowledge, which seem to have been Bacon's ruling passions! But such was the obstinacy of his temper, and his overweening self-conceit, that, instead of co-operating with Bacon in the execution of his magnificent design, he resolved to rear, on a foundation exclusively his own, a complete structure both of Moral and Physical science; disdaining to avail himself even of the materials collected by his predecessors, and treating the *experimentarian* philosophers as objects only of contempt and ridicule![1]

In the *political* writings of Hobbes, we may perceive the influence also of other motives. From his earliest years, he seems to have been decidedly hostile to all the forms of popular government; and it is said to have been with the design of impressing his countrymen with a just sense of the disorders incident to democratical establishments, that he published, in 1618, an English translation of Thucydides. In these opinions he was more and more confirmed by the events he afterwards witnessed in England; the fatal consequences of which he early foresaw with so much alarm, that, in 1640, he withdrew from the approaching storm, to enjoy the society of his philosophical friends at Paris. It was here he wrote his book *De Cive*, a few copies of which were printed, and privately circulated in 1642. The same work was afterwards given to the public, with material corrections and improvements, in 1647, when the author's attachment to the royal cause being strengthened by his personal connection with the exiled King, he thought it incumbent on him to stand forth avowedly as an advocate for those principles which he had long professed. The great object of this performance was to strengthen the hands of sovereigns against the rising spirit of democracy, by arming them with the weapons of a new philosophy.

The fundamental doctrines inculcated in the political works of Hobbes are contained in the following propositions. I recapitulate them here, not on their own account, but to prepare the way for some remarks which I mean afterwards to offer on the coincidence between the principles of Hobbes and those of Locke. In their practical conclusions, indeed, with respect to the rights and duties of citizens, the two writers differ widely; but it is curious to observe how very nearly they set out from the same hypothetical assumptions.

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[1] See Note G.

All men are by nature equal; and, prior to government, they had all an equal right to enjoy the good things of this world. Man, too, is (according to Hobbes) by nature a solitary and purely selfish animal; the social union being entirely an interested league, suggested by prudential views of personal advantage. The necessary consequence is, that a state of nature must be a state of perpetual warfare, in which no individual has any other means of safety than his own strength or ingenuity; and in which there is no room for regular industry, because no secure enjoyment of its fruits. In confirmation of this view of the origin of society, Hobbes appeals to facts falling daily within the circle of our own experience. "Does not a man (he asks) when taking a journey, arm himself, and seek to go well accompanied? When going to sleep, does he not lock his doors? Nay, even in his own house, does he not lock his chests? Does he not *there* as much accuse mankind by his actions, as I do by my words?"[1] An additional argument to the same purpose may, according to some later Hobbists, be derived from the instinctive aversion of infants for strangers; and from the apprehension which (it is alleged) every person feels, when he hears the tread of an unknown foot in the dark.

For the sake of peace and security, it is necessary that each individual should surrender a part of his natural right, and be contented with such a share of liberty as he is willing to allow to others; or, to use Hobbes's own language, "every man must divest himself of the right he has to all things by nature; the right of all men to all things being in effect no better than if no man had a right to any thing."[2] In consequence of this transference of natural rights to an individual, or to a body of individuals, the multitude become one person, under the name of a State or Republic, by which person the common will and power are exercised for the common defence. The ruling power cannot be withdrawn from those to whom it has been committed; nor can they be punished for misgovernment. The interpretation of the laws is to be sought, not from the comments of philosophers, but from the authority of the ruler; otherwise society would every moment be in danger of resolving itself into the discordant elements of which it was at first composed. The will of the magistrate, therefore, is to be regarded as the ultimate standard of right and wrong, and his voice to be listened to by every citizen as the voice of conscience.

Not many years afterwards,[3] Hobbes pushed the argument for the absolute power of princes still further, in a work to which he gave the name of *Leviathan*. Under

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[1] *Of Man*, Part I. chap. xiii.

[2] *De Corpore Politico*, Part I. chap. i. § 10.

[3] In 1651.

this appellation he means the *body politic ;* insinuating, that man is an untameable beast of prey, and that government is the strong chain by which he is kept from mischief. The fundamental principles here maintained are the same as in the book *De Cive ;* but as it inveighs more particularly against *ecclesiastical* tyranny, with the view of subjecting the consciences of men to the civil authority, it lost the author the favour of some powerful protectors he had hitherto enjoyed among the English divines who attended Charles II. in France ; and he even found it convenient to quit that kingdom, and to return to England, where Cromwell (to whose government his political tenets were *now* as favourable as they were meant to be to the royal claims) suffered him to remain unmolested. The same circumstances operated to his disadvantage after the Restoration, and obliged the King, who always retained for him a very strong attachment, to confer his marks of favour on him with the utmost reserve and circumspection. [1]

The details which I have entered into, with respect to the history of Hobbes's political writings, will be found, by those who may peruse them, to throw much light on the author's reasonings. Indeed, it is only by thus considering them in their connection with the circumstances of the times, and the fortunes of the writer, that a just notion can be formed of their spirit and tendency.

The ethical principles of Hobbes are so completely interwoven with his political system, that all which has been said of the one may be applied to the other. It is very remarkable, that Descartes should have thought so highly of the former, as to pronounce Hobbes to be "a much greater master of morality than of metaphysics ;" a judgment which is of itself sufficient to mark the very low state of ethical science in France about the middle of the seventeenth century. Mr Addison, on the other hand, gives a decided preference (among all the books written by Hobbes) to his *Treatise on Human Nature ;* and to *his* opinion on this point I most implicitly subscribe ; including, however, in the same commendation, some of his other philosophical essays on similar topics. They are the only part of his works which it is possible now to read with any interest ; and they everywhere evince in their author, even when he thinks most unsoundly himself, that power of setting his reader a-thinking, which is one of the most unequivocal marks of original genius. They have plainly been studied with the utmost care both by Locke and Hume. To the former they have suggested some of his most important observations on the Association of Ideas, as well as much of the sophistry displayed in the first book of his Essay, on the Origin of our Knowledge, and on the factitious nature of our moral principles ; to the latter (among a variety of hints of less consequence),

[1] See Note H.

his theory concerning the nature of those established connections among physical events, which it is the business of the natural philosopher to ascertain,[1] and the substance of his argument against the scholastic doctrine of general conceptions. It is from the works of Hobbes, too, that our later Necessitarians have borrowed the most formidable of those weapons with which they have combated the doctrine of moral liberty; and from the same source has been derived the leading idea which runs through the philological materialism of Mr Horne Tooke. It is probable, indeed, that this last author borrowed it, at second-hand, from a hint in Locke's Essay; but it is repeatedly stated by Hobbes, in the most explicit and confident terms. Of this idea, (than which, in point of fact, nothing can be imagined more puerile and unsound,) Mr Tooke's etymologies, when he applies them to the solution of metaphysical questions, are little more than an ingenious expansion, adapted and levelled to the comprehension of the multitude.

The speculations of Hobbes, however, concerning the theory of the understanding, do not seem to have been nearly so much attended to during his own life, as some of his other doctrines, which, having a more immediate reference to human affairs, were better adapted to the unsettled and revolutionary spirit of the times. It is by these doctrines, chiefly, that his name has since become so memorable in the annals of modern literature; and although they now derive their whole interest from the extraordinary combination they exhibit of acuteness and subtlety with a dead-palsy in the powers of taste and of moral sensibility, yet they will be found, on an attentive examination, to have had a far more extensive influence on the subsequent history both of political and of ethical science, than any other publication of the same period.

## Antagonists of Hobbes.

Cudworth[2] was one of the first who successfully combated this new philosophy. As Hobbes, in the frenzy of his political zeal, had been led to sacrifice wantonly all the prin-

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[1] The same doctrine, concerning the proper object of natural philosophy (commonly ascribed to Mr Hume, both by his followers and by his opponents), is to be found in various writers contemporary with Hobbes. It is stated, with uncommon precision and clearness, in a book entitled *Scepsis Scientifica*, or Confessed Ignorance the way to Science; by Joseph Glanvill, (printed in 1665.) The whole work is strongly marked with the features of an acute, an original, and (in matters of science) a somewhat sceptical genius; and, when compared with the treatise on witchcraft, by the same author, adds another proof to those already mentioned, of the possible union of the highest intellectual gifts with the most degrading intellectual weaknesses.

With respect to the *Scepsis Scientifica*, it deserves to be noticed, that the doctrine maintained in it concerning *physical* causes and effects does not occur in the form of a detached observation, of the value of which the author might not have been fully aware, but is the very basis of the general argument running through all his discussions.

[2] Born 1617, died 1688.

ciples of religion and morality to the establishment of his conclusions, his works not only gave offence to the friends of liberty, but excited a general alarm among all sound moralists. His doctrine, in particular, that there is no *natural* distinction between Right and Wrong, and that these are dependent on the arbitrary will of the civil magistrate, was so obviously subversive of all the commonly received ideas concerning the moral constitution of human nature, that it became indispensably necessary, either to expose the sophistry of the attempt, or to admit, with Hobbes, that man is a beast of prey, incapable of being governed by any motives but fear, and the desire of self-preservation.

Between some of these tenets of the courtly Hobbists, and those inculcated by the Cromwellian Antinomians, there was a very extraordinary and unfortunate coincidence; the latter insisting, that, in expectation of Christ's second coming, "the obligations of morality and natural law were suspended; and that the elect, guided by an internal principle, more perfect and divine, were superior to the *beggarly elements* of justice and humanity."[1] It was the object of Cudworth to vindicate, against the assaults of both parties, the immutability of moral distinctions.

In the prosecution of his very able argument on this subject, Cudworth displays a rich store of enlightened and choice erudition, penetrated throughout with a peculiar vein of sobered and subdued Platonism, from whence some German systems, which have attracted no small notice in our own times, will be found, when stripped of their deep neological disguise, to have borrowed their most valuable materials.[2]

Another coincidence between the Hobbists and the Antinomians, may be remarked in

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[1] Hume.——For a more particular account of the English Antinomians, See Mosheim, Vol. IV. p. 534, *et seq.*

[2] The mind (according to Cudworth) perceives, by occasion of outward objects, as much more than is represented to it by sense, as a learned man does in the best written book, than an illiterate person or brute. "To the eyes of both, the same characters will appear; but the learned man, in those characters, will see heaven, earth, sun, and stars; read profound theorems of philosophy or geometry; learn a great deal of new knowledge from them, and admire the wisdom of the composer; while, to the other, nothing appears but black strokes drawn on white paper. The reason of which is, that the mind of the one is furnished with certain previous inward anticipations, ideas, and instruction, that the other wants."—"In the room of this book of *human* composition, let us now substitute the book of Nature, written all over with the characters and impressions of *divine* wisdom and goodness, but legible only to an intellectual eye. To the sense both of man and brute, there appears nothing else in it, but, as in the other, so many inky scrawls; that is, nothing but figures and colours. But the mind, which hath a participation of the divine wisdom that made it, upon occasion of those sensible delineations, exerting its own inward activity, will have not only a wonderful scene, and large prospects of other thoughts laid open before it, and variety of knowledge, logical, mathematical, and moral displayed; but also clearly read the divine wisdom and goodness in every page of this great volume, as it were written in large and legible characters."

I do not pretend to be an adept in the philosophy of Kant; but I certainly think I pay it a very high com-

their common zeal for the scheme of *necessity ;* which both of them stated in such a way as to be equally inconsistent with the moral agency of man, and with the moral attributes of God.[1] The strongest of all presumptions against this scheme is afforded by the other tenets with which it is almost universally combined ; and accordingly, it was very shrewdly observed by Cudworth, that *the licentious system* which flourished in his time (under which title, I presume, he comprehended the immoral tenets of the fanatics, as well as of the Hobbists), " grew up from the doctrine of the fatal necessity of all actions and events, as from its proper root." The unsettled, and, at the same time, disputatious period during which Cudworth lived, afforded him peculiarly favourable opportunities of judging from experience, of the practical tendency of this metaphysical dogma ; and the result of his observations deserves the serious attention of those who may be disposed to regard it in the light of a fair and harmless theme for the display of controversial subtilty. To argue, in this manner, against a speculative principle from its palpable effects, is not always so illogical as some authors have supposed. " You repeat to me incessantly," says Rousseau to one of his correspondents, " that truth can never be injurious to the world. I myself believe so as firmly as you do ; and it is for this very reason I am satisfied that your proposition is false." [2]

But the principal importance of Cudworth, as an ethical writer, arises from the influence of his argument concerning the immutability of right and wrong on the various theories of

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pliment, when I suppose, that, in the *Critic of pure Reason*, the leading idea is somewhat analogous to what is so much better expressed in the foregoing passage. To Kant it was probably suggested by the following very acute and decisive remark of Leibnitz on Locke's Essay : " Nempe, nihil est in intellectu, quod non fuerit in sensu, *nisi ipse intellectus*."

In justice to Aristotle, it may be here observed, that, although the general strain of his language is strictly conformable to the scholastic maxim just quoted, he does not seem to have altogether overlooked the important exception to it pointed out by Leibnitz. Indeed, this exception or limitation is very nearly a translation of Aristotle's words. *Και αυτος δε νους νοητος εστιν, ὥσπερ τα νοητα. επι μεν γαρ των ανευ ὑλης, το αυτο εστι το νοουν καὶ το νοουμενον.* " And the mind itself is an object of knowledge, as well as other things which are intelligible. For, in immaterial beings, that which understands is the same with that which is understood." (De *Anima*, Lib. iii. cap. v.) I quote this very curious, and, I suspect, very little known sentence, in order to vindicate Aristotle against the misrepresentations of some of his present idolaters, who, in their anxiety to secure to him all the credit of Locke's doctrine concerning the Origin of our Ideas, have overlooked the occasional traces which occur in his works, of that higher and sounder philosophy in which he had been educated.

[1] " The doctrines of fate or destiny were deemed by the Independents essential to all religion. In these rigid opinions, *the whole sectaries*, amidst all their other differences, unanimously concurred." Hume's *History*, chap. lvii.

[2] " Vous répétez sans cesse que la vérité ne peut jamais faire de mal aux hommes ; je le crois, et c'est pour moi la preuve que ce que vous dites n'est pas la vérité."

morals which appeared in the course of the eighteenth century. To this argument may, more particularly, be traced the origin of the celebrated question, Whether the principle of moral approbation is to be ultimately resolved into Reason, or into Sentiment?—a question, which has furnished the chief ground of difference between the systems of Cudworth and of Clarke, on the one hand; and those of Shaftesbury, Hutcheson, Hume, and Smith, on the other. The remarks which I have to offer on this controversy must evidently be delayed, till the writings of these more modern authors shall fall under review.

The *Intellectual System* of Cudworth, embraces a field much wider than his treatise of *Immutable Morality*. The latter is particularly directed against the ethical doctrines of Hobbes, and of the Antinomians; but the former aspires to tear up by the roots all the principles, both physical and metaphysical, of the Epicurean philosophy. It is a work, certainly, which reflects much honour on the talents of the author, and still more on the boundless extent of his learning; but it is so ill suited to the taste of the present age, that, since the time of Mr Harris and Dr Price, I scarcely recollect the slightest reference to it in the writings of our British metaphysicians. Of its faults (beside the general disposition of the author to discuss questions placed altogether beyond the reach of our faculties), the most prominent is the wild hypothesis of a *plastic nature*; or, in other words, "of a vital and spiritual, but unintelligent and necessary agent, created by the Deity for the execution of his purposes." Notwithstanding, however, these, and many other abatements of its merits, *the Intellectual System* will for ever remain a precious mine of information to those whose curiosity may lead them to study the spirit of the ancient theories; and to *it* we may justly apply what Leibnitz has somewhere said, with far less reason, of the works of the schoolmen, "Scholasticos agnosco abundare ineptiis; *sed aurum est in illo cœno*."[1]

Before dismissing the doctrines of Hobbes, it may be worth while to remark, that all his leading principles are traced by Cudworth to the remains of the ancient sceptics, by some of whom, as well as by Hobbes, they seem to have been adopted from a wish to flatter the uncontrolled passions of sovereigns. Not that I am disposed to call in question the originality of Hobbes; for it appears, from the testimony of all his friends, that he had much less pleasure in reading than in thinking. "If I had read," he was accustomed to say, "as much as some others, I should have been as ignorant as they are." But similar political circumstances invariably reproduce similar philosophical theories; and it is one of the numer-

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[1] The *Intellectual System* was published in 1678. The *Treatise concerning Eternal and Immutable Morality* did not appear till a considerable number of years after the author's death.

ous disadvantages attending an inventive mind, not properly furnished with acquired information, to be continually liable to a waste of its powers on subjects previously exhausted.

The sudden tide of licentiousness, both in principles and in practice, which burst into this island at the moment of the Restoration, conspired with the paradoxes of Hobbes, and with the no less dangerous errors recently propagated among the people by their religious instructors, to turn the thoughts of sober and speculative men towards ethical disquisitions. The established clergy assumed a higher tone than before in their sermons; sometimes employing them in combating that Epicurean and Machiavellian philosophy which was then fashionable at court, and which may be always suspected to form the secret creed of the enemies of civil and religious liberty;—on other occasions, to overwhelm, with the united force of argument and learning, the extravagancies by which the ignorant enthusiasts of the preceding period had exposed Christianity itself to the scoffs of their libertine opponents. Among the divines who appeared at this era, it is impossible to pass over in silence the name of Barrow, whose theological works (adorned throughout by classical erudition, and by a vigorous, though unpolished eloquence), exhibit, in every page, marks of the same inventive genius which, in mathematics, has secured to him a rank second alone to that of Newton. As a writer, he is equally distinguished by the redundancy of his matter, and by the pregnant brevity of his expression; but what more peculiarly characterizes his manner, is a certain air of powerful and of conscious facility in the execution of whatever he undertakes. Whether the subject be mathematical, metaphysical, or theological, he seems always to bring to it a mind which feels itself superior to the occasion; and which, in contending with the greatest difficulties, "puts forth but half its strength." He has somewhere spoken of his *Lectiones Mathematicæ* (which it may, in passing, be remarked, display *metaphysical* talents of the highest order), as extemporaneous effusions of his pen; and I have no doubt that the same epithet is still more literally applicable to his pulpit discourses. It is, indeed, only thus we can account for the variety and extent of his voluminous remains, when we recollect that the author died at the age of forty-six.[1]

To the extreme rapidity with which Barrow committed his thoughts to writing, I am inclined to ascribe the hasty and not altogether consistent opinions which he has hazarded on

[1] In a note annexed to an English translation of the Cardinal Maury's *Principles of Eloquence*, it is stated, upon the authority of a manuscript of Dr Doddridge, that *most* of Barrow's sermons were transcribed three times, and some much oftener. They seem to me to contain very strong intrinsic evidence of the incorrectness of this anecdote.—Mr Abraham Hill, (in his *Account of the Life of Barrow*, addressed to Dr Tillot-

some important topics. I shall confine myself to a single example, which I select in preference to others, as it bears directly on the most interesting of all questions connected with the theory of morals. " If we scan," says he, " the particular nature, and search into the original causes of the several kinds of naughty dispositions in our souls, and of miscarriages in our lives, we shall find inordinate self-love to be a main ingredient, and a common source of them all ; so that a divine of great name had some reason to affirm,—that *original sin* (or that innate distemper from which men generally become so very prone to evil, and averse to good), doth consist in self-love, disposing us to all kinds of irregularity and excess." In another passage, the same author expresses himself thus : " Reason dictateth and prescribeth to us, that we should have a sober regard to our true good and welfare ; to our best interests and solid content ; to that which (all things being rightly stated, considered and computed) will, in the final event, prove most beneficial and satisfactory to us : a self-love working in prosecution of such things, common sense cannot but allow and approve."

Of these two opposite and irreconcilable opinions, the latter is incomparably the least wide of the truth ; and accordingly Mr Locke, and his innumerable followers, both in England and on the Continent, have maintained, that virtue and an enlightened self-love are one and the same. I shall afterwards find a more convenient opportunity for stating some objections to the latter doctrine, as well as to the former. I have quoted the two passages here, merely to shew the very little attention that had been paid, at the era in question, to ethical science, by one of the most learned and profound divines of his age. This is the more remarkable, as his works everywhere inculcate the purest lessons of practical morality, and evince a singular acuteness and justness of eye in the observation of human character. Whoever compares the views of Barrow, when he touches on the theory of morals, with those opened about fifty years afterwards by Dr Butler, in his *Discourses on Human Nature*, will be abundantly satisfied, that, in this science, as well as in others, the progress of the philosophical spirit during the intervening period was not inconsiderable.

The name of Wilkins, (although he too wrote with some reputation against the Epicureans of his day), is now remembered chiefly in consequence of his treatises concerning *a universal language and a real character*. Of these treatises, I shall hereafter have occa-

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son), contents himself with saying, that " *Some* of his sermons were written four or five times over ;"—mentioning, at the same time, a circumstance which may account for this fact, in perfect consistency with what I have stated above,—that " Barrow was very ready to *lend* his sermons as often as desired."

sion to take some notice, under a different article. With all the ingenuity displayed in them, they cannot be considered as accessions of much value to science; and the long period since elapsed, during which no attempt has been made to turn them to any practical use, affords of itself no slight presumption against the solidity of the project.

A few years before the death of Hobbes, Dr Cumberland (afterwards Bishop of Peterborough) published a book, entitled, *De Legibus Naturæ, Disquisitio Philosophica;* the principal aim of which was to confirm and illustrate, in opposition to Hobbes, the conclusions of Grotius, concerning *Natural Law.* The work is executed with ability, and discovers juster views of the object of moral science, than any modern system that had yet appeared; the author resting the strength of his argument, not, as Grotius had done, on an accumulation of authorities, but on the principles of the human frame, and the mutual relations of the human race. The circumstance, however, which chiefly entitles this publication to *our* notice is, that it seems to have been the earliest on the subject which attracted, in any considerable degree, the attention of English scholars. From this time, the writings of Grotius and of Puffendorff began to be generally studied, and soon after made their way into the Universities. In Scotland, the impression produced by them was more peculiarly remarkable. They were everywhere adopted as the best manuals of ethical and of political instruction that could be put into the hands of students; and gradually contributed to form that memorable school, from whence so many Philosophers and Philosophical Historians were afterwards to proceed.

From the writings of Hobbes to those of Locke, the transition is easy and obvious; but, before prosecuting farther the history of philosophy in England, it will be proper to turn our attention to its progress abroad, since the period at which this section commences. [1] In

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[1] Through the whole of this Discourse, I have avoided touching on the discussions which, on various occasions, have arisen with regard to the theory of government, and the comparative advantages or disadvantages of different political forms. Of the scope and spirit of these discussions it would be seldom possible to convey a just idea, without entering into details of a local or temporary nature, inconsistent with my general design. In the present circumstances of the world, besides, the theory of government (although, in one point of view, the most important of all studies) seems to possess a very subordinate interest to inquiries connected with political economy, and with the fundamental principles of legislation. What is it, indeed, that renders one form of government more favourable than another to human happiness, but the superior security it provides for the enactment of wise laws, and for their impartial and vigorous execution? These considerations will sufficiently account for my passing over in silence, not only the names of Needham, of Sidney, and of Milton, but that of Harrington, whose *Oceana* is justly regarded as one of the boasts of English literature, and is pronounced by Hume to be "the only valuable model of a commonwealth that has yet been offered to the public." (*Essays and Treatises,* Vol. I. Essay xvi.)

A remark which Hume has elsewhere made on the *Oceana,* appears to me so striking and so instructive, that I shall give it a place in this note. "Harrington," he observes, "thought himself so sure of his general

the first place, however, I shall add a few miscellaneous remarks on some important events which occurred in this country during the lifetime of Hobbes, and of which his extraordinary longevity prevented me sooner from taking notice.

Among these events, that which is most immediately connected with our present subject, is the establishment of the Royal Society of London in 1662, which was followed a few years afterwards by that of the Royal Academy of Sciences at Paris. The professed object of both institutions was the improvement of Experimental Knowledge, and of the auxiliary science of Mathematics; but their influence on the general progress of human reason has been far greater than could possibly have been foreseen at the moment of their foundation. On the happy effects resulting from them in this respect, La Place has introduced some just reflections in his *System of the World*, which, as they discover more originality of thought than he commonly displays, when he ventures to step beyond the circumference of his own magic circle, I shall quote, in a literal translation of his words.

"The chief advantage of learned societies, is the *philosophical spirit* to which they may be expected to give birth, and which they cannot fail to diffuse over all the various pursuits of the nations among whom they are established. The insulated scholar may without dread abandon himself to the spirit of system; he hears the voice of contradiction only from afar. But in a learned society, the collision of systematic opinions soon terminates in their common destruction; while the desire of mutual conviction creates among the members a tacit compact, to admit nothing but the results of observation, or the conclusions of mathematical reasoning. Accordingly, experience has shewn, how much these establishments have contributed, since their origin, to the spread of true philosophy. By setting the example of submitting every thing to the examination of a severe logic, they have dissipated the prejudices which had too long reigned in the sciences; and which the strongest minds of the preceding centuries had not been able to resist. They have constantly opposed to empiricism a mass of knowledge, against which the errors adopted by the vulgar, with an enthusiasm which, in former times, would have perpetuated their empire, have spent their force in vain. In a word, it has been in their bosoms that those grand theories have been con-

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principle, *that the balance of power depends on that of property*, that he ventured to pronounce it impossible ever to re-establish monarchy in England: But his book was scarcely published when the King was restored; and we see that monarchy has ever since subsisted on the same footing as before. So dangerous is it for a politician to venture to foretel the situation of public affairs a few years hence." Ibid. Essay vii.

How much nearer the truth (even in the science of *politics*) is Bacon's cardinal principle, that *knowledge* is power!—a principle, which applies to Man not less in his corporate than in his individual capacity; and which may be safely trusted to as the most solid of all foundations for our reasonings concerning the future history of the world.

ceived, which, although far exalted by their generality above the reach of the multitude, are for this very reason entitled to special encouragement, from their innumerable applications to the phenomena of nature, and to the practice of the arts." [1]

In confirmation of these judicious remarks, it may be farther observed, that nothing could have been more happily imagined than the establishment of learned corporations for correcting those prejudices which (under the significant title of *Idola Specus*,) Bacon has described as incident to the retired student. While these *idols of the den* maintain their authority, the cultivation of the philosophical spirit is impossible; or rather, it is in a renunciation of this idolatry that the philosophical spirit essentially consists. It was accordingly in this great school of the learned world, that the characters of Bacon, Descartes, Leibnitz, and Locke were formed; the four individuals who have contributed the most to diffuse the philosophical spirit over Europe. The remark applies more peculiarly to Bacon, who first pointed out the inconveniences to be apprehended from a minute and mechanical subdivision of literary labour; and anticipated the advantages to be expected from the institution of learned academies, in enlarging the field of scientific curiosity, and the correspondent grasp of the emancipated mind. For accomplishing this object, what means so effectual as habits of daily intercourse with men whose pursuits are different from our own; and that expanded knowledge, both of man and of nature, of which such an intercourse must necessarily be productive!

Another event which operated still more forcibly and universally on the intellectual character of our countrymen, was the civil war which began in 1640, and which ultimately terminated in the usurpation of Cromwell. It is observed by Mr Hume, that "the prevalence of democratical principles, under the Commonwealth, engaged the country gentlemen to bind their sons apprentices to merchants; and that commerce has ever since been more honourable in England, than in any other European kingdom." [2] "The higher and the lower ranks (as a later writer has remarked) were thus brought closer together, and all of them inspired with an activity and vigour that, in former ages, had no example." [3]

To this combination of the pursuits of trade, with the advantages of a liberal education may be ascribed the great multitude of ingenious and enlightened speculations on commerce,

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[1] The Royal Society of London, though not incorporated by charter till 1662, may be considered as virtually existing, at least as far back as 1638, when some of the most eminent of the original members began first to hold regular meetings at Gresham College, for the purpose of philosophical discussion. Even these meetings were but a continuation of those previously held by the same individuals, at the apartments of Dr Wilkins in Oxford, See Sprat's *History of the Royal Society*.

[2] *History of England*, Chap. lxii.

[3] Chalmers's *Political Estimate*, &c. (London 1804.) p. 44.

and on the other branches of national industry, which issued from the press, in the short interval between the Restoration and the Revolution; an interval during which the sudden and immense extension of the trade of England, and the corresponding rise of the commercial interest, must have presented a spectacle peculiarly calculated to awaken the curiosity of inquisitive observers. It is a very remarkable circumstance with respect to these economical researches, which now engage so much of the attention both of statesmen and of philosophers, that they are altogether of modern origin. "There is scarcely," says Mr Hume, "any ancient writer on politics who has made mention of trade; nor was it ever considered as an affair of state till the seventeenth century." [1]——The work of the celebrated John de Witt, entitled, "The true interest and political maxims of the republic of Holland and West Friesland," is the earliest publication of any note, in which commerce is treated of as an object of *national* and *political* concern, in opposition to the partial interests of corporations and of monopolists.

Of the English publications to which I have just alluded, the greater part consists of anonymous pamphlets, now only to be met with in the collections of the curious. A few bear the names of eminent English merchants. I shall have occasion to refer to them more particularly afterwards, when I come to speak of the writings of Smith, Quesnay, and Turgot. At present, I shall only observe, that, in these fugitive and now neglected tracts, are to be found the first rudiments of that science of *Political Economy* which is justly considered as the boast of the present age; and which, although the aid of learning and philosophy was necessary to rear it to maturity, may be justly said to have had its cradle in the Royal Exchange of London.

Mr Locke was one of the first retired theorists (and this singular feature in his history has not been sufficiently attended to by his biographers), who condescended to treat of *trade* as an object of liberal study. Notwithstanding the manifold errors into which he fell in the course of his reasonings concerning it, it may be fairly questioned, if he has anywhere else given greater proofs, either of the vigour or of the originality of his genius. But the name of Locke reminds me, that it is now time to interrupt these national details; and to turn our attention to the progress of science on the Continent, since the times of Bodinus and of Campanella.

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[1] *Essay of Civil Liberty.*

## Section II.

### *Progress of Philosophy in France during the Seventeenth Century.*

### Montaigne—Charron—La Rochefoucauld.

At the head of the French writers who contributed, in the beginning of the seventeenth century, to turn the thoughts of their countrymen to subjects connected with the Philosophy of Mind, Montaigne may, I apprehend, be justly placed. Properly speaking, he belongs to a period somewhat earlier; but his tone of thinking and of writing classes him much more naturally with his successors, than with any French author who had appeared before him.[1]

In assigning to Montaigne so distinguished a rank in the history of modern philosophy, I need scarcely say, that I leave entirely out of the account what constitutes (and justly constitutes) to the generality of readers the principal charm of his Essays; the good nature, humanity, and unaffected sensibility, which so irresistibly attach us to his character,—lending, it must be owned, but too often, a fascination to his *talk*, when he cannot be recommended as the safest of companions. Nor do I lay much stress on the inviting frankness and vivacity with which he unbosoms himself about all his domestic habits and concerns; and which render his book so expressive a portrait, not only of the author, but of the Gascon country-gentleman, two hundred years ago. I have in view chiefly the minuteness and good faith of his details concerning his own personal qualities, both intellectual and moral. The only study which seems ever to have engaged his attention was that of *man*; and for this he was singularly fitted, by a rare combination of that talent for observation which belongs to men of the world, with those habits of abstracted reflection, which men of the world have commonly so little disposition to cultivate. "I study myself," says he, "more than any other subject. This is my metaphysic; this my natural philosophy."[2] He has accordingly produced a work, *unique* in its kind; valuable, in an eminent degree, as an authentic record of many interesting facts relative to human nature; but more valuable by far, as holding up a mirror in which every individual, if he does not see his own image, will at least occasionally perceive so many traits of resemblance to it, as can scarcely fail to invite his curiosity to a more careful review of himself. In this respect, Montaigne's writings may be regarded in the

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[1] Montaigne was born in 1533, and died in 1592.

[2] *Essays*, Book iii. chap. xiii.

light of what painters call *studies;* in other words, of those slight sketches which were originally designed for the improvement or amusement of the artist; but which, on that account, are the more likely to be useful in developing the germs of similar endowments in others.

Without a union of these two powers (reflection and observation), the study of Man can never be successfully prosecuted. It is only by retiring within ourselves that we can obtain a key to the characters of others; and it is only by observing and comparing the characters of others that we can thoroughly understand and appreciate our own.

After all, however, it may be fairly questioned, notwithstanding the scrupulous fidelity with which Montaigne has endeavoured to delineate his own portrait, if he has been always sufficiently aware of the secret folds and reduplications of the human heart. That he was by no means exempted from the common delusions of self-love and self-deceit, has been fully evinced in a very acute, though somewhat uncharitable, section of the *Port-Royal* logic; but this consideration, so far from diminishing the value of his Essays, is one of the most instructive lessons they afford to those who, after the example of the author, may undertake the salutary but humiliating task of self-examination.

As Montaigne's scientific knowledge was, according to his own account, "very vague and imperfect;"[1] and his book-learning rather sententious and gossipping, than comprehensive and systematical, it would be unreasonable to expect, in his philosophical arguments, much either of depth or of solidity.[2] The sentiments he hazards are to be regarded but as the impressions of the moment; consisting chiefly of the more obvious doubts and difficulties which, on all metaphysical and moral questions, are apt to present themselves to a speculative mind, when it first attempts to dig below the surface of common opinions. In reading Montaigne, accordingly, what chiefly strikes us, is not the novelty or the refinement of his ideas, but the liveliness and felicity with which we see embodied in words the previous wanderings of our own imaginations. It is probably owing to this circumstance, rather than to any direct plagiarism, that his Essays appear to contain the germs of so many of the paradoxical theories which, in later times, Helvetius and others have laboured to systematise and to support with the parade of metaphysical discussion. In the mind of Montaigne, the same paradoxes may be easily traced to those deceitful *appearances* which, in order to sti-

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[1] Book i. chap. xxv.

[2] Montaigne's education, however, had not been neglected by his father. On the contrary, he tells us himself, that "George Buchanan, the great poet of Scotland, and Marcus Antonius Muretus, the best orator of his time, were among the number of his domestic preceptors."—"Buchanan," he adds, "when I saw him afterwards in the retinue of the late Mareschal de Brissac, told me, that he was about to write a treatise on the education of children, and that he would take the model of it from mine." Book i. chap. xxv.

mulate our faculties to their best exertions, nature seems purposely to have thrown in our way, as stumbling-blocks in the pursuit of truth ; and it is only to be regretted on such occasions, for the sake of his own happiness, that his genius and temper qualified and disposed him more to start the problem than to investigate the solution.

When Montaigne touches on religion, he is, in general, less pleasing than on other subjects. His constitutional temper, it is probable, predisposed him to scepticism ; but this original bias could not fail to be mightily strengthened by the disputes, both religious and political, which, during his lifetime, convulsed Europe, and more particularly his own country. On a mind like his it may be safely presumed, that the writings of the reformers, and the instructions of Buchanan, were not altogether without effect ; and hence, in all probability, the perpetual struggle, which he is at no pains to conceal, between the creed of his infancy, and the lights of his mature understanding. He speaks, indeed, of "reposing tranquilly on the *pillow of doubt ;*" but this language is neither reconcilable with the general complexion of his works, nor with the most authentic accounts we have received of his dying moments. It is a maxim of his own, that, "in forming a judgment of a man's life, particular regard should be paid to his behaviour at the end of it ;" to which he pathetically adds, "that the chief study of his own life was, that his latter end might be decent, calm, and silent." The fact is (if we may credit the testimony of his biographers), that, in his declining years, he exchanged his boasted *pillow of doubt* for the more powerful opiates prescribed by the infallible church ; and that he expired in performing what his old preceptor Buchanan would not have scrupled to describe as an act of idolatry. [1]

The scepticism of Montaigne seems to have been of a very peculiar cast, and to have had little in common with that either of Bayle or of Hume. The great aim of the two latter writers evidently was, by exposing the uncertainty of our reasonings whenever we pass the limit of sensible objects, to inspire their readers with a complete distrust of the human faculties on all moral and metaphysical topics. Montaigne, on the other hand, never thinks of forming a sect ; but, yielding passively to the current of his reflections and feelings, argues, at different times, according to the varying state of his impressions and temper, on opposite sides of the same question. On all occasions, he preserves an air of the most perfect sincerity ; and it was to *this*, I presume, much more than to the superiority of his reasoning powers, that Montesquieu alluded, when he said, "In the greater part of authors I see the *writer ;* in Montaigne I see nothing but the *thinker.*" The radical fault of his

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[1] "Sentant sa fin approcher, il fit dire la messe dans sa chambre. A l'élévation de l'hostie, il se leva sur son lit pour l'adorer ; mais une foiblesse l'enleva dans ce moment même, le 15 Septembre 1592, à 60 ans." *Nouveau Dict. Histor.* à Lyon, 1804. Art. Montaigne.

understanding consisted in an incapacity of forming, on disputable points, those decided and fixed opinions which can alone impart either force or consistency to intellectual character. For remedying this weakness, the religious controversies, and the civil wars recently engendered by the Reformation, were but ill calculated. The minds of the most serious men, all over Christendom, must have been then unsettled in an extraordinary degree; and where any predisposition to scepticism existed, every external circumstance must have conspired to cherish and confirm it. Of the extent to which it was carried, about the same period, in England, some judgment may be formed from the following description of a *Sceptic* by a writer not many years posterior to Montaigne.

"A sceptic in religion is one that hangs in the balance with all sorts of opinions; whereof not one but stirs him, and none sways him. A man guiltier of credulity than he is taken to be; for it is out of his belief of everything that he believes nothing. Each religion scares him from its contrary, none persuades him to itself. He would be wholly a Christian, but that he is something of an Atheist; and wholly an Atheist, but that he is partly a Christian; and a perfect Heretic, but that there are so many to distract him. He finds *reason* in all opinions, *truth* in none; indeed, the least reason perplexes him, and the best will not satisfy him. He finds doubts and scruples better than resolves them, and *is always too hard for himself*."[1] If this portrait had been presented to Montaigne, I have little doubt that he would have had the candour to acknowledge, that he recognized in it some of the most prominent and characteristical features of his own mind.[2]

The most elaborate, and seemingly the most serious, of all Montaigne's essays, is his long and somewhat tedious *Apology for Raimond de Sebonde*, contained in the twelfth chapter of his second book. This author appears, from Montaigne's account, to have been a Spaniard, who professed physic at Thoulouse, towards the end of the fourteenth century; and who published a treatise, entitled *Theologia Naturalis*, which was put into the hands of Montaigne's father by a friend, as a useful antidote against the innovations with which Luther was then beginning to disturb the ancient faith. That, in this particular instance, the

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[1] *Micro-cosmography*, or a Piece of the World Discovered, in Essays and Characters. For a short notice of the author of this very curious book (Bishop Earle), See *Letters from the Bodleian Library*, Vol. I. p. 141. I understand it has been lately reprinted in London, but have only seen one of the old editions (the seventh), printed in 1638. The chapter from which I have transcribed the above passage is entitled *A Sceptic in Religion;* and it has plainly suggested to Lord Clarendon some of the ideas, and even expressions, which occur in his account of Chillingworth.

[2] "The writings of the best authors among the ancients," Montaigne tells us on one occasion, "being full and solid, tempt and carry me which way almost they will. He that I am reading seems always to have the most force; and I find that every one in turn has reason, though they contradict one another." Book ii. chap. xii.

book answered the intended purpose, may be presumed from the request of old Montaigne to his son, a few days before his death, to translate it into French from the Spanish original. His request was accordingly complied with; and the translation is referred to by Montaigne in the first edition of his *Essays*, printed at Bourdeaux in 1580; but the execution of this filial duty seems to have produced on Montaigne's own mind very different effects from what his father had anticipated.[1]

The principal aim of Sebonde's book, according to Montaigne, is to show that "Christians are in the wrong to make human reasoning the basis of their belief, since the object of it is only conceived by faith, and by a special inspiration of the divine grace." To this doctrine Montaigne professes to yield an implicit assent; and, under the shelter of it, contrives to give free vent to all the extravagancies of scepticism. The essential distinction between the reason of man, and the instincts of the lower animals, is at great length, and with no inconsiderable ingenuity, disputed; the powers of the human understanding, in all inquiries, whether physical or moral, are held up to ridicule; an universal Pyrrhonism is recommended; and we are again and again reminded, that "*the senses are the beginning and the end of all our knowledge.*" Whoever has the patience to peruse this chapter with attention, will be surprised to find in it the rudiments of a great part of the licentious philosophy of the eighteenth century; nor can he fail to remark the address with which the author avails himself of the language afterwards adopted by Bayle, Helvetius, and Hume:—"That, to be a philosophical sceptic, is the first step towards becoming a sound believing Christian."[2] It is a melancholy fact in ecclesiastical history, that this insidious maxim should have been sanctioned, in our times, by some theologians of no common pretensions to orthodoxy; who, in direct contradiction to the words of Scripture, have ventured to assert, that "he who comes to God must first believe that he is NOT." Is it necessary to remind these grave retailers of Bayle's sly and ironical sophistry, that every argument for Christianity, drawn from its *internal* evidence, tacitly recognizes the authority of human reason; and assumes, as the ultimate *criteria* of truth and of falsehood, of right and of wrong, certain fundamental articles of belief, discoverable by the light of Nature?[3]

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[1] The very few particulars known with respect to Sebonde have been collected by Bayle. See his *Dictionary*, Art. Sebonde.

[2] This expression is Mr Hume's; but the same proposition, in substance, is frequently repeated by the two other writers, and is very fully enlarged upon by Bayle in the *Illustration upon the Sceptics*, annexed to his Dictionary.

[3] "I once asked *Adrian Turnebus*," says Montaigne, "what he thought of Sebonde's treatise? The answer he made to me was, That he believed it to be some extract from *Thomas Aquinas*, for that none but a genius like his was capable of such ideas."

I must not, however, omit to mention, that a very learned Protestant, *Hugo Grotius*, has expressed him-

Charron is well known as the chosen friend of Montaigne's latter years, and as the confidential depositary of his philosophical sentiments. Endowed with talents far inferior in force and originality to those of his master, he possessed, nevertheless, a much sounder and more regulated judgment; and as his reputation, notwithstanding the liberality of some of his peculiar tenets, was high among the most respectable and conscientious divines of his own church, it is far from improbable, that Montaigne committed to him the guardianship of his posthumous fame, from motives similar to those which influenced Pope, in selecting Warburton as his literary executor. The discharge of this trust, however, seems to have done less good to Montaigne than harm to Charron; for, while the unlimited scepticism, and the indecent levities of the former, were viewed by the zealots of those days with a smile of tenderness and indulgence, the slighter heresies of the latter were marked with a severity the more rigorous and unrelenting, that, in points of essential importance, they deviated so very little from the standard of the Catholic faith. It is not easy to guess the motives of this inconsistency; but such we find from the fact to have been the temper of religious bigotry, or, to speak more correctly, of political religionism, in all ages of the world.[1]

As an example of Charron's solicitude to provide an antidote against the more pernicious

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self to his friend *Bignon* not unfavourably of Sebonde's intentions, although the terms in which he speaks of him are somewhat equivocal, and imply but little satisfaction with the execution of his design. "Non ignoras quantum excoluerint istam materiam *(argumentum scil. pro Religione Christiana) philosophica subtilitate* Raimundus Sebundus, dialogorum varietate Ludovicus Vives, maxima autem tum eruditione tum facundia vestras Philippus Mornæus." The authors of the *Nouveau Dictionnaire Historique* (Lyons, 1804) have entered much more completely into the spirit and drift of Sebonde's reasoning, when they observe, "Ce livre offre des singularités hardies, qui plurent dans le temps aux philosophes de ce siècle, et *qui ne déplairoient pas à ceux du notre.*"

It is proper to add, that I am acquainted with Sebonde only through the *medium* of Montaigne's version, which does not lay claim to the merit of strict fidelity; the translator himself having acknowledged, that he had given to the Spanish philosopher "un accoutrement à la Françoise, et qu'il l'a dévêtu de son port farouche et maintien barbaresque, de manière qu'il a mes-hui assez de façon pour se présenter en toute bonne compagnie."

[1] Montaigne, cet auteur charmant,
Tour à-tour profond et frivole,
Dans son chateau paisiblement,
Loin de tout frondeur malévole
Doutoit de tout impunément,
Et se moquoit très librement
Des bavards fourrés de l'école.
Mais quand son élève Charron,
Plus retenu, plus méthodique,
De sagesse donna leçon,
Il fut près de périr, dit on,
Par la haine théologique.

Voltaire, *Epitre au Président Hénault.*

errors of his friend, I shall only mention his ingenious and philosophical attempt to reconcile, with the moral constitution of human nature, the apparent discordancy in the judgments of different nations concerning right and wrong. His argument on this point is in substance the very same with that so well urged by Beattie, in opposition to Locke's reasonings against the existence of innate practical principles. It is difficult to say, whether, in this instance, the coincidence between Montaigne and Locke, or that between Charron and Beattie, be the more remarkable. [1]

Although Charron has affected to give to his work a systematical form, by dividing and subdividing it into books and chapters, it is in reality little more than an unconnected series of essays on various topics, more or less distantly related to the science of Ethics. On the powers of the understanding he has touched but slightly; nor has he imitated Montaigne, in anatomizing, for the edification of the world, the peculiarities of his own moral character. It has probably been owing to the desultory and popular style of composition common to both, that so little attention has been paid to either by those who have treated of the history of French philosophy. To Montaigne's merits, indeed, as a lively and amusing essayist, ample justice has been done; but his influence on the subsequent habits of thinking among his countrymen remains still to be illustrated. He has done more, perhaps, than any other author (I am inclined to think with the most honest intentions), to introduce *into mens houses* (if I may borrow an expression of Cicero) what is now called the *new philosophy*,—a philosophy certainly very different from that of Socrates. In the fashionable world, he has, for more than two centuries, maintained his place as the first of moralists; a circumstance easily accounted for, when we attend to the singular combination, exhibited in his writings, of a semblance of erudition, with what Malebranche happily calls his *air du monde*, and *air cavalier*. [2] As for the graver and less attractive Charron, his name would probably before now have sunk into oblivion, had it not been so closely associated, by the accidental events of his life, with the more celebrated name of Montaigne. [3]

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[1] See Beattie's *Essay on Fable and Romance;* and Charron *de la Sagesse*, Liv. ii. c. 8. It may amuse the curious reader also to compare the theoretical reasonings of Charron with a Memoir in the *Phil. Trans.* for 1773 (by Sir Roger Curtis), containing *some particulars with respect to the country of Labradore.*

[2] "Ah l'aimable homme, *qu'il est de bonne compagnie!* C'est mon ancien ami; mais, à force d'être ancien, il m'est nouveau." Madame de Sevigné.

[3] Montaigne himself seems, from the general strain of his writings, to have had but little expectation of the posthumous fame which he has so long continued to enjoy. One of his reflections on this head is so characteristical of the author as a man; and, at the same time, affords so fine a specimen of the graphical powers of his now antiquated style, that I am tempted to transcribe it in his own words: "J'écris mon livre à peu d'hommes et à peu d'années; s'il ç'eût été une matière de durée, il l'eût fallu commettre à un langage plus ferme. Selon la variation continuelle qui a suivi le nôtre jusqu'à cette heure, qui peut espérer que sa forme

The preceding remarks lead me, by a natural connection of ideas (to which I am here much more inclined to attend than to the order of dates), to another writer of the seventeenth century, whose influence over the literary and philosophical taste of France has been far greater than seems to be commonly imagined. I allude to the Duke of La Rochefoucauld, author of the *Maxims* and *Moral Reflections*.

Voltaire was, I believe, the first who ventured to assign to La Rochefoucauld the preeminent rank which belongs to him among the French classics. "One of the works," says he, "which contributed most to form the taste of the nation to a justness and precision of thought and expression, was the small collection of maxims by Francis Duke of La Rochefoucauld. Although there be little more than one idea in the book, that *self-love is the spring of all our actions*, yet this idea is presented in so great a variety of forms, as to be always amusing. When it first appeared, it was read with avidity; and it contributed, more than any other performance since the revival of letters, to improve the vivacity, correctness, and delicacy of French composition."

Another very eminent judge of literary merit (the late Dr Johnson) was accustomed to say of La Rochefoucauld's *Maxims*, that it was almost the only book written by a man of fashion, of which professed authors had reason to be jealous. Nor is this wonderful, when we consider the unwearied industry of the very accomplished writer, in giving to every part of it the highest and most finished polish which his exquisite taste could bestow. When he had committed a maxim to paper, he was in use to circulate it among his friends, that he might avail himself of their critical animadversions; and, if we may credit Segrais, altered some of them no less than thirty times, before venturing to submit them to the public eye.

That the tendency of these maxims is, upon the whole, unfavourable to morality, and that they always leave a disagreeable impression on the mind, must, I think, be granted. At the same time, it may be fairly questioned, if the motives of the author have in general been well understood, either by his admirers or his opponents. In affirming that self-love is the spring of all our actions, there is no good reason for supposing that he meant to deny the reality of moral distinctions as a philosophical truth;—a supposition quite inconsistent with his own fine and deep remark, that *hypocrisy is itself an homage which vice renders to virtue.* He states it merely as *a fact*, which, in the course of his experience as a man of

présente soit en usage d'ici à cinquante ans? il écoule tous les jours de nos mains, et depuis que je vis, s'est altéré de moitié. Nous disons qu'il est à cette heure parfait: Autant en dit du sien chaque siècle. *C'est aux bons et utiles écrits de le clouer à eux, et ira sa fortune selon le crédit de notre état.*"

How completely have both the predictions in the last sentence been verified by the subsequent history of the French language!

the world, he had found very generally verified in the higher classes of society; and which he was induced to announce without any qualification or restriction, in order to give more force and poignancy to his satire. In adopting this mode of writing, he has unconsciously conformed himself, like many other French authors, who have since followed his example, to a suggestion which Aristotle has stated with admirable depth and acuteness in his Rhetoric. "Sentences or apophthegms lend much aid to eloquence. One reason of this is, that they flatter the *pride* of the hearers, who are delighted when the speaker, making use of general language, touches upon opinions which they had before known to be true in part. Thus, a person who had the misfortune to live in a bad neighbourhood, or to have worthless children, would easily assent to the speaker who should affirm, that *nothing* is more vexatious than to have any neighbours; *nothing* more irrational than to bring children into the world."[1] This observation of Aristotle, while it goes far to account for the imposing and dazzling effect of these rhetorical exaggerations, ought to guard us against the common and popular error of mistaking them for the serious and profound generalizations of science. As for La Rochefoucauld, we know, from the best authorities, that, in private life, he was a conspicuous example of all those moral qualities of which he seemed to deny the existence; and that he exhibited, in this respect, a striking contrast to the Cardinal de Retz, who has presumed to censure him for his want of faith in the reality of virtue.

In reading La Rochefoucauld, it should never be forgotten, that it was within the vortex of a court he enjoyed his chief opportunities of studying the world; and that the narrow and exclusive circle in which he moved was not likely to afford him the most favourable specimens of human nature in general. Of the Court of Lewis XIV. in particular, we are told by a very nice and reflecting observer (Madame de la Fayette), that "ambition and gallantry were *the soul*, actuating alike both men and women. So many contending interests, so many different cabals were constantly at work, and in all of these, women bore so important a part, that love was always mingled with business, and business with love. Nobody was tranquil or indifferent. Every one studied to advance himself by pleasing, serving, or ruining others. Idleness and languor were unknown, and nothing was thought of but intrigues or pleasures."

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[1] Εχουσι δε (γνωμαι) εις τους λογους βοηθειαν μεγαλην, μιαν μεν δη δια φορτικοτητα των ακροατων· χαιρουσι γαρ, εαν τις καθολου λεγων, επιτυχη των δοξων, ἁς εκεινοι κατα μερος εχουσιν.—Ἡ μεν γαρ γνωμη, ὥσπερ ειρηται, καθολου αποφανσις εστι· χαιρουσι δε καθολου λεγομενου, ὃ κατα μερος προϋπολαμβανοντες τυγχανουσιν· ὁιον, ειτις γειτοσι τυχη κεχρημενος, η τεκνοις φαυλοις, αποδεξαιτ' αν του ειποντος, ουδεν γειτονιας χαλεπωτερον· η, ὁτι ουδεν ηλιθιωτερον τεκνοποΐας. Arist. *Rhet.* Lib. ii. c. xxi.

The whole chapter is interesting and instructive, and shews how profoundly Aristotle had meditated the principles of the rhetorical art.

In the passage already quoted from Voltaire, he takes notice of the effect of La Rochefoucauld's maxims, in improving the style of French composition. We may add to this remark, that their effect has not been less sensible in vitiating the tone and character of French philosophy, by bringing into vogue those false and degrading representations of human nature and of human life, which have prevailed in that country, more or less, for a century past. Mr Addison, in one of the papers of the *Tatler*, expresses his indignation at this general bias among the French writers of his age. "It is impossible," he observes, "to read a passage in Plato or Tully, and a thousand other ancient moralists, without being a greater and better man for it. On the contrary, I could never read any of our modish French authors, or those of our own country, who are the imitators and admirers of that nation, without being, for some time, out of humour with myself, and at everything about me. Their business is to depreciate human nature, and to consider it under the worst appearances; they give mean interpretations, and base motives to the worthiest actions. In short, they endeavour to make no distinction between man and man, or between the species of man and that of the brutes."[1]

It is very remarkable, that the censure here bestowed by Addison on the fashionable French wits of his time, should be so strictly applicable to Helvetius, and to many other of the most admired authors whom France has produced in our own day. It is still more remarkable to find the same depressing spirit shedding its malignant influence on French literature, as early as the time of La Rochefoucauld, and even of Montaigne; and to observe how very little has been done by the successors of these old writers, but to expand into grave philosophical systems their loose and lively paradoxes;—disguising and fortifying them by the aid of those logical principles, to which the name and authority of Locke have given so wide a circulation in Europe.

In tracing the origin of that false philosophy on which the excesses of the French revolutionists have entailed such merited disgrace, it is usual to remount no higher than to the profligate period of the Regency; but the seeds of its most exceptionable doctrines had been sown in that country at an earlier era, and were indebted for the luxuriancy of their harvest, much more to the political and religious soil where they struck their roots, than to the skill or foresight of the individuals by whose hands they were scattered.

I have united the names of Montaigne and of La Rochefoucauld, because I consider their writings as rather addressed to the world at large, than to the small and select class of spe-

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[1] *Tatler*, No. 103. The last paper of the *Tatler* was published in 1711; and, consequently, the above passage must be understood as referring to the *modish* tone of French philosophy, prior to the death of Louis XIV.

culative students. Neither of them can be said to have enriched the stock of human knowledge by the addition of any one important general conclusion; but the maxims of both have operated very extensively and powerfully on the taste and principles of the higher orders all over Europe, and predisposed them to give a welcome reception to the same ideas, when afterwards reproduced with the imposing appendages of logical method, and of a technical phraseology. The foregoing reflections, therefore, are not so foreign as might at first be apprehended, to the subsequent history of ethical and of metaphysical speculation. It is time, however, now to turn our attention to a subject far more intimately connected with the general progress of human reason,—the philosophy of Descartes.

## Descartes—Gassendi—Malebranche.

According to a late writer,[1] whose literary decisions (excepting where he touches on religion or politics) are justly entitled to the highest deference, Descartes has a better claim than any other individual, to be regarded as the father of that spirit of free inquiry, which, in modern Europe, has so remarkably displayed itself in all the various departments of knowledge. Of Bacon, he observes, "that though he possessed, in a most eminent degree, the genius of philosophy, he did not unite with it the genius of the sciences; and that the methods proposed by him for the investigation of truth, consisting entirely of precepts which he was unable to exemplify, had little or no effect in accelerating the rate of discovery." As for Galileo, he remarks, on the other hand, "that his exclusive taste for mathematical and physical researches, disqualified him for communicating to the general mind that impulse of which it stood in need."

"This honour," he adds, "was reserved for Descartes, who combined in himself the characteristical endowments of both his predecessors. If, in the physical sciences, his march be less sure than that of Galileo—if his logic be less cautious than that of Bacon—yet the very temerity of his errors was instrumental to the progress of the human race. He gave activity to minds which the circumspection of his rivals could not awake from their lethargy. He called upon men to throw off the yoke of authority, acknowledging no influence but what reason should avow: And his call was obeyed by a multitude of followers, encouraged by the boldness, and fascinated by the enthusiasm of their leader."

In these observations, the ingenious author has rashly generalized a conclusion deduced from the literary history of his own country. That the works of Bacon were but little read there till after the publication of D'Alembert's Preliminary Discourse, is, I believe,

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[1] Condorcet.

an unquestionable fact;[1] *not* that it necessarily follows from this, that, even in France, no previous effect had been produced by the labours of Boyle, of Newton, and of the other English experimentalists, trained in Bacon's school. With respect to England, it is a fact not less certain, that at no period did the philosophy of Descartes produce such an impression on public opinion, either in Physics or in Ethics, as to give the slightest colour to the supposition, that it contributed, in the most distant degree, to the subsequent advances made by our countrymen in these sciences. In Logic and Metaphysics, indeed, the case was different. Here the writings of Descartes did much; and if they had been studied with proper attention, they might have done much more. But of *this* part of their merits, Condorcet seems to have had no idea. His eulogy, therefore, is rather misplaced than excessive. He has extolled Descartes as the father of Experimental Physics: He would have been nearer the truth, if he had pointed him out as the father of the Experimental Philosophy of the Human Mind.

In bestowing this title on Descartes, I am far from being inclined to compare him, in the number or importance of *the facts* which he has remarked concerning our intellectual powers, to various other writers of an earlier date. I allude merely to his clear and precise conception of that operation of the understanding (distinguished afterwards in Locke's *Essay* by the name of *Reflection)*, through the medium of which all our knowledge of Mind is exclusively to be obtained. Of the essential subserviency of this power to every satisfactory conclusion that can be formed with respect to the mental phenomena, and of the futility of every theory which would attempt to explain them by metaphors borrowed from the material world, no other philosopher prior to Locke seems to have been fully aware; and from the moment that these truths were recognized as logical principles in the study of *mind*, a new era commences in the history of that branch of science. It will be necessary, therefore, to allot to the illustration of this part of the Cartesian philosophy a larger space, than the limits of my undertaking will permit me to afford to the researches of some succeeding inquirers, who may, at first sight, appear more worthy of attention in the present times.

It has been repeatedly asserted by the Materialists of the last century, that Descartes was the first Metaphysician by whom the pure immateriality of the human soul was taught; and that the ancient philosophers, as well as the schoolmen, went no farther than to con-

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[1] One reason for this is well pointed out by D'Alembert. "Il n'y a que les chefs de secte en tout genre, dont les ouvrages puissent avoir un certain éclat; Bacon n'a pas été du nombre, et la forme de sa philosophie s'y opposoit: elle étoit trop sage pour étonner personne." *Disc. Prel.*

sider *mind* as the result of a material organization, in which the constituent elements approached to evanescence, in point of subtlety. Both of these propositions I conceive to be totally unfounded. That many of the schoolmen, and that the wisest of the ancient philosophers, when they described the mind as a *spirit*, or as a *spark of celestial fire*, employed these expressions, *not* with any intention to materialize its essence, but merely from want of more unexceptionable language, might be shewn with demonstrative evidence, if this were the proper place for entering into the discussion. But what is of more importance to be attended to, on the present occasion, is the effect of Descartes' writings in disentangling the *logical principle* above mentioned, from the *scholastic* question about the nature of *mind*, as contradistinguished from *matter*. It were indeed to be wished, that he had perceived still more clearly and steadily the essential importance of keeping this distinction constantly in view; but he had at least the merit of illustrating, by his own example, in a far greater degree than any of his predecessors, the possibility of studying the mental phenomena, without reference to any facts but those which rest on the evidence of consciousness. The metaphysical question about the *nature* of mind he seems to have considered as a problem, the solution of which was an easy corollary from these *facts*, if distinctly apprehended; but still as a problem, whereof it was possible that different views might be taken by those who agreed in opinion, as far as *facts* alone were concerned. Of this a very remarkable example has since occurred in the case of Mr Locke, who, although he has been at great pains to shew, that the power of *reflection* bears the same relation to the study of the mental phenomena, which the power of *observation* bears to the study of the material world, appears, nevertheless, to have been far less decided than Descartes with respect to the essential distinction between Mind and Matter; and has even gone so far as to hazard the unguarded proposition, that there is no absurdity in supposing the Deity to have superadded to the other qualities of matter *the power of thinking*. His scepticism, however, on this point, did not prevent his good sense from perceiving, with the most complete conviction, the indispensable necessity of abstracting from the analogy of matter, in studying the laws of our intellectual frame.

The question about the nature or essence of the soul, has been, in all ages, a favourite subject of discussion among Metaphysicians, from its supposed connection with the argument in proof of its immortality. In this light it has plainly been considered by both parties in the dispute; the one conceiving, that if Mind could be shewn to have no quality in common with Matter, its *dissolution* was physically impossible; the other, that if this assumption could be disproved, it would necessarily follow, that the *whole man* must perish at death. For the last of these opinions Dr Priestley and many other speculative theologians have of late very zealously contended; flattering themselves, no doubt, with the idea,

that they were thus preparing a triumph for their own peculiar schemes of Christianity. Neglecting, accordingly, all the presumptions for a future state, afforded by a comparison of the course of human affairs with the moral judgments and moral feelings of the human heart; and overlooking, with the same disdain, the presumptions arising from the narrow sphere of human knowledge, when compared with the indefinite improvement of which our intellectual powers seem to be susceptible; this acute but superficial writer attached himself exclusively to the old and hackneyed pneumatological argument; tacitly assuming as a principle, that the future prospects of man depend entirely on the determination of a *physical* problem, analogous to that which was then dividing chemists about the existence or non-existence of Phlogiston. In the actual state of science, these speculations might well have been spared. Where is the sober metaphysician to be found, who now speaks of the immortality of the soul as a logical consequence of its immateriality; instead of considering it as depending on the will of that Being by whom it was at first called into existence? And, on the other hand, is it not universally admitted by the best philosophers, that whatever hopes the light of nature encourages beyond the present scene, rest solely (like all our other anticipations of future events) on the general tenor and analogy of the laws by which we perceive the universe to be governed? The proper use of the argument concerning *the immateriality of mind*, is not to establish any positive conclusion as to its destiny hereafter; but to repel the reasonings alleged by materialists, as proofs that its annihilation must be the obvious and necessary effect of the dissolution of the body.[1]

I thought it proper to state this consideration pretty fully, lest it should be supposed that the logical method recommended by Descartes for studying the phenomena of mind, has any necessary dependence on his metaphysical opinion concerning its being and properties, as a separate substance.[2] Between these two parts of his system, however, there is, if not a

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[1] "We shall here be content," says the learned John Smith of Cambridge, "with that sober thesis of Plato, in his *Timæus*, who attributes the perpetuation of all substances to the benignity and liberality of the Creator; whom he therefore brings in thus speaking, ὑμεις ὑκ εστε αθανατοι ὑδ᾽ αλυτοι, &c. *You are not of yourselves immortal nor indissoluble, but would relapse and slide back from that being which I have given you, should I withdraw the influence of my own power from you; but yet you shall hold your immortality by a patent from myself.*" (*Select Discourses*, Cambridge, 1660.) I quote this passage from one of the oldest partizans of Descartes among the English philosophers.

Descartes himself is said to have been of a different opinion. "On a été étonné," says Thomas, "que dans ses *Méditations Métaphysiques*, Descartes n'ait point parlé de l'immortalité de l'ame. Mais il nous apprend lui-même par une de ses lettres, qu'ayant établi clairement, dans cet ouvrage, la distinction de l'ame et de la matière, il suivoit nécessairement de cette distinction, que l'ame par sa nature ne pouvoit périr avec le corps." *Eloge de Descartes.* Note 21.

[2] I employ the scholastic word *substance*, in conformity to the phraseology of Descartes, but I am fully aware of the strong objections to which it is liable, not only as a wide deviation from popular use, which has appropriated it to things material and tangible, but as implying a greater degree of positive knowledge con-

demonstrative connection, at least a natural and manifest affinity; inasmuch as a steady adherence to his logical method (or, in other words, the habitual exercise of patient *reflection*), by accustoming us to break asunder the obstinate associations to which materialism is indebted for the early hold it is apt to take of the fancy, gradually and insensibly predisposes us in favour of his metaphysical conclusion. It is to be regretted, that, in stating this conclusion, his commentators should so frequently make use of the word *spirituality*; for which I do not recollect that his own works afford any authority. The proper expression is *immateriality*, conveying merely a negative idea; and, of consequence, implying nothing more than a rejection of that hypothesis concerning the nature of Mind, which the scheme of materialism so gratuitously, yet so dogmatically assumes.[1]

The power of Reflection, it is well known, is the last of our intellectual faculties that unfolds itself; and, in by far the greater number of individuals, it never unfolds itself in any considerable degree. It is a fact equally certain, that, long before the period of life when this power begins to exercise its appropriate functions, the understanding is already preöccupied with a chaos of opinions, notions, impressions and associations, bearing on the most important objects of human inquiry; not to mention the innumerable sources of illusion and error connected with the use of a vernacular language, learned in infancy by rote, and identified with the first processes of thought and perception. The consequence is, that when Man begins to reflect, he finds himself (if I may borrow an allusion of M. Turgot's) lost in a labyrinth, into which he had been led blindfolded.[2] To the same purpose, it was long ago complained of by Bacon, "that no one has yet been found of so constant and severe a mind, as to have determined and tasked himself utterly to abolish theories and common notions, and to apply his intellect, altogether smoothed and even, to particulars anew. Accordingly, that human reason which we have, is a kind of medley and unsorted collection, from much trust and much accident, and the childish notions which we first drank in. Whereas, if one of ripe age and sound senses, and a mind thoroughly cleared, should apply himself freshly to experiment and particulars, of him were better things to be hoped."

What Bacon has here recommended, Descartes attempted to execute; and so exact is the coincidence of his views on this fundamental point with those of his predecessor, that it is

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cerning the nature of *mind*, than our faculties are fitted to attain.—For some farther remarks on this point, See Note I.

[1] See Note K.

[2] "Quand l'homme a voulu se replier sur lui-meme il s'est trouvé dans un labyrinthe où il étoit entré les yeux bandés." *Oeuvres de Turgot*, Tom. II. p. 261.

with difficulty I can persuade myself that he had never read Bacon's works.[1] In the prosecution of this undertaking, the first steps of Descartes are peculiarly interesting and instructive; and it is *these* alone which merit our attention at present. As for the details of his system, they are now curious only as exhibiting an amusing contrast to the extreme rigour of the principle from whence the author sets out; a contrast so very striking, as fully to justify the epigrammatic saying of D'Alembert, that "Descartes began with doubting of everything, and ended in believing that he had left nothing unexplained."

Among the various articles of common belief which Descartes proposed to subject to a severe scrutiny, he enumerates particularly, the conclusiveness of mathematical demonstration; the existence of God; the existence of the material world; and even the existence of his own body. The only thing that appeared to him certain and incontrovertible, was his own existence; by which he repeatedly reminds us, we are to understand merely the existence of *his mind*, abstracted from all consideration of the material organs connected with it. About every other proposition, he conceived, that doubts might reasonably be entertained; but to suppose the non-existence of *that* which thinks, at the very moment it is conscious of thinking, appeared to him a contradiction in terms. From this single postulatum, accordingly, he took his departure; resolved to admit nothing as a philosophical truth, which could not be deduced from it by a chain of logical reasoning.[2]

Having first satisfied himself of his own existence, his next step was to inquire, how far his perceptive and intellectual faculties were entitled to credit. For this purpose, he begins with offering a proof of the existence and attributes of God;—truths which he conceived to be necessarily involved in the idea he was able to form of a perfect, self-existent, and eternal being. His reasonings on this point it would be useless to state. It is sufficient to observe, that they led him to conclude, that God cannot possibly be supposed to deceive his creatures; and therefore, that the intimations of our senses, and the decisions of our reason, are to be trusted to with entire confidence, wherever they afford us *clear and distinct ideas* of their respective objects.[3]

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[1] See Note L.

[2] "Sic autem rejicientes illa omnia, de quibus aliquo modo possumus dubitare, ac etiam falsa esse fingentes, facile quidem supponimus nullum esse Deum, nullum cœlum, nulla corpora; nosque etiam ipsos, non habere manus, nec pedes, nec denique ullum corpus; non autem ideo nos qui talia cogitamus nihil esse: repugnat enim, ut putemus id quod cogitat, eo ipso tempore quo cogitat, non existere. Ac proinde hæc cognitio, *ego cogito, ergo sum*, est omnium prima et certissima, quæ cuilibet ordine philosophanti occurrat." *Princip. Philos.* Pars I. § 7.

[3] The substance of Descartes' argument on these fundamental points, is thus briefly recapitulated by himself in the conclusion of his third Meditation:—"Dum in meipsum mentis aciem converto, non modo intelli-

As Descartes conceived the existence of God (next to the existence of his own mind) to be the most indisputable of all truths, and rested his confidence in the conclusions of human reason entirely on his faith in the divine veracity, it is not surprising that he should have rejected the argument from *final causes*, as superfluous and unsatisfactory. To have availed himself of its assistance, would not only have betrayed a want of confidence in what he professed to regard as much more certain than any mathematical theorem; but would obviously have exposed him to the charge of first appealing to the divine attributes in proof of the authority of his faculties; and afterwards, of appealing to these faculties, in proof of the existence of God.

It is wonderful, that it should have escaped the penetration of this most acute thinker, that a *vicious circle* of the same description is involved in every appeal to the intellectual powers, in proof of their own credibility; and that unless this credibility be assumed as unquestionable, the farther exercise of human reason is altogether nugatory. The evidence for the existence of God seems to have appeared to Descartes too irresistible and overwhelming, to be subjected to those logical canons which apply to all the other conclusions of the understanding.[1]

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go me esse rem incompletam, et ab alio dependentem, remque ad majora et meliora indefinite aspirantem, sed simul etiam intelligo illum, à quo pendeo, majora ista omnia non indefinite et potentia tantum, sed reipsa infinite in se habere, atque ita Deum esse; totaque vis argumenti in eo est, quod agnoscam fieri non posse ut existem talis naturæ qualis sum, nempe ideam Dei in me habens, nisi revera Deus etiam existeret, Deus, inquam, ille idem cujus idea in me est, hoc est habens omnes illas perfectiones quas ego non comprehendere sed quocunque modo attingere cogitatione possum, et nullis planè defectibus obnoxius. Ex his satis patet, illum fallacem esse non posse: omnem enim fraudem et deceptionem à defectu aliquo pendere lumine naturali manifestum est."

The above argument for the existence of God (very improperly called by some foreigners an argument *a priori*), was long considered by the most eminent men in Europe as quite demonstrative. For my own part, although I do not think that it is by any means so level to the apprehension of common inquirers, as the argument from the marks of *design* everywhere manifested in the universe, I am still less inclined to reject it as altogether unworthy of attention. It is far from being so metaphysically abstruse as the reasonings of Newton and Clarke, founded on our conceptions of *space* and of *time;* nor would it appear, perhaps, less logical and conclusive than that celebrated demonstration, if it were properly unfolded, and stated in more simple and popular terms. The two arguments, however, are, in no respect, exclusive of each other; and I have always thought, that, by combining them together, a proof of the point in question might be formed, more impressive and luminous than is to be obtained from either, when stated apart.

[1] How painful is it to recollect, that the philosopher who had represented his faith in the veracity of God, as the sole foundation of his confidence in the demonstrations of mathematics, was accused and persecuted by his contemporaries as an atheist; and *that*, too, in the same country (Holland), where, for more than half a century after his death, his doctrines were to be taught in all the universities with a blind idolatry! A zeal without knowledge, and the influence of those earthly passions, from which even protestant divines are not always exempted, may, it is to be hoped, go far to account for this

Extravagant and hopeless as these preliminary steps must now appear, they had nevertheless an obvious tendency to direct the attention of the author, in a singular degree, to the phenomena of thought; and to train him to those habits of abstraction from external objects, which, to the bulk of mankind, are next to impossible. In this way, he was led to perceive, with the evidence of consciousness, that the attributes of Mind were still more clearly and distinctly knowable than those of Matter; and that, in studying the former, so far from attempting to explain them by analogies borrowed from the latter, our chief aim ought to be, to banish as much as possible from the fancy every analogy, and even every analogical expression, which, by inviting the attention abroad, might divert it from its proper business at home. In one word, that the only right method of philosophising on this subject was comprised in the old stoical precept (understood in a sense somewhat different from that originally annexed to it) *nec te quæsiveris extra.* A just conception of this rule, and a steady adherence to its spirit, constitutes the ground-work of what is properly called the Experimental Philosophy of the Human Mind. It is thus that all our facts relating to Mind must be ascertained; and it is only upon facts thus attested by our own consciousness, that any just theory of Mind can be reared.

Agreeably to these views, Descartes, was, I think, the first who clearly saw, that our idea of Mind is not direct but relative;—relative to the various operations of which we are conscious. What am I? he asks, in his second Meditation: A thinking being,—that is, a being doubting, knowing, affirming, denying, consenting, refusing, susceptible of pleasure and of pain.[1] Of all these things I might have had complete experience, without any previous acquaintance with the qualities and laws of matter; and therefore it is impossible that the study of matter can avail me aught in the study of myself. This, accordingly, Descartes laid down as a first principle; that *nothing comprehensible by the imagination can be at all subservient to the knowledge of Mind;* and that the sensible images involved in all our common forms of speaking concerning its operations, are to be guarded against with the most anxious care, as tending to confound, in our apprehensions, two classes of phenomena, which it is of the last importance to distinguish accurately from each other.[2]

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inconsistency and injustice, without adopting the uncharitable insinuation of D'Alembert: " Malgré toute la sagacité qu'il avoit employée pour prouver l'existence de Dieu, il fut accusé de la nier par *des ministres, qui peut-être ne la croyoient pas.*"

[1] " Non sum compages illa membrorum, quæ corpus humanum appellatur; non sum etiam tenuis aliquis aër istis membris infusus; non ventus, non ignis, non vapor, non halitus——Quid igitur sum? res cogitans; quid est hoc? nempe dubitans, intelligens, affirmans, negans, volens, nolens," &c. *Med. Sec.*

[2] " Itaque cognosco, nihil eorum quæ possum *Imaginatione* comprehendere, ad hanc quam de me habeo notitiam pertinere; mentemque ab illis diligentissime esse avocandam, ut suam ipsa naturam quàm distinctis-

To those who are familiarly acquainted with the writings of Locke, and of the very few among his successors who have thoroughly entered into the spirit of his philosophy, the foregoing observations may not appear to possess much either of originality or of importance; but when first given to the world, they formed the greatest step ever made in the science of Mind, by a single individual. What a contrast do they exhibit, not only to the discussions of the schoolmen, but to the analogical theories of Hobbes at the very same period! and how often have they been since lost sight of, notwithstanding the clearest speculative conviction of their truth and importance, by Locke himself, and by the greatest part of his professed followers! Had they been duly studied and understood by Mr Horne Tooke, they would have furnished him with a key for solving those etymological riddles, which, although mistaken by many of his contemporaries for profound philosophical discoveries, derive, in fact, the whole of their mystery, from the strong bias of shallow reasoners to *relapse* into the same scholastic errors, from which Descartes, Locke, Berkeley, Hume, and Reid, have so successfully laboured to emancipate the mind.

If anything can add to our admiration of a train of thought manifesting in its author so unexampled a triumph over the strongest prejudices of sense, it is the extraordinary circumstance of its having first occurred to a young man, who had spent the years commonly

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sime percipiat. Ibid. A few sentences before, Descartes explains with precision in what sense *Imagination* is here to be understood. "Nihil aliud est *imaginari* quam rei corporeæ figuram seu imaginem contemplari."

The following extracts from a book published at Cambridge in 1660 (precisely ten years after the death of Descartes), while they furnish a useful comment on some of the above remarks, may serve to shew, how completely the spirit of the Cartesian philosophy of Mind had been seized, even *then*, by some of the members of that university.

"The souls of men exercising themselves first of all κινησει προβατικῆ, as the Greek philosopher expresseth himself, merely by a *progressive kind of motion*, spending themselves about bodily and material acts, and conversing only with sensible things; they are apt to acquire such deep stamps of material phantasms to themselves, that they cannot imagine their own *Being* to be any other than *material* and *divisible*, though of a fine ethereal nature. It is not possible for us well to know what our souls are, but only by their κινησεις κυκλικαι, their *circular or reflex motions*, and converse with themselves, which can only steal from them their own secrets." Smith's *Select Discourses*, p. 65, 66.

"If we reflect but upon our own souls, how manifestly do the notions of *reason*, *freedom*, *perception*, and the like, offer themselves to us, whereby we may *know* a thousand times *more distinctly* what our souls are than what our bodies are. For the former, we know by an immediate converse with ourselves, and a distinct sense of their operations; whereas all our knowledge of the body is little better than merely historical, which we gather up by scraps and piecemeal, from more doubtful and uncertain experiments which we make of them; but the notions which we have of a *mind*, *i. e.* something within us that thinks, apprehends, reasons, and discourses, are so clear and distinct from all those notions which we can fasten upon a body, that we can easily conceive that if all *body-being* in the world were destroyed, yet we might then as well subsist as now we do." Ibid. p. 98.

devoted to academical study, amid the dissipation and tumult of camps.[1] Nothing could make this conceivable, but the very liberal education which he had previously received under the Jesuits, at the college of *La Flèche*;[2] where, we are told, that while yet a boy, he was so distinguished by habits of deep meditation, that he went among his companions by the name of *the Philosopher*. Indeed, it is only at that early age, that such habits are to be cultivated with complete success.

The glory, however, of having pointed out to his successors the true method of studying the theory of *Mind*, is almost all that can be claimed by Descartes in logical and metaphysical science. Many important hints, indeed, may be gleaned from his works; but, on the whole, he has added very little to our knowledge of human nature. Nor will this appear surprising, when it is recollected, that he aspired to accomplish a similar revolution in all the various departments of physical knowledge;—not to mention the time and thought he must have employed in those mathematical researches, which, however lightly esteemed by himself, have been long regarded as the most solid basis of his fame.[3]

Among the principal articles of the Cartesian philosophy, which are now incorporated with our prevailing and most accredited doctrines, the following seem to me to be chiefly entitled to notice!

1. His luminous exposition of the common logical error of attempting to define words

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[1] "Descartes porta les armes, d'abord en Hollande, sous le célèbre Maurice de Nassau; de-là en Allemagne, sous Maximilien de Bavière, au commencement de la guerre de trente ans. Il passa ensuite au service de l'Empereur Ferdinand II. pour voir de plus près les troubles de la Hongrie. On croit aussi, qu'au siège de la Rochelle, il combattit, comme volontaire, dans une bataille contre la flotte Angloise." Thomas, *Eloge de Descartes*, Note 8.

When Descartes quitted the profession of arms, he had arrived at the age of twenty-five.

[2] It is a curious coincidence, that it was in the same village of *La Flèche* that Mr Hume fixed his residence, while composing his Treatise of Human Nature. Is it not probable, that he was partly attracted to it, by associations similar to those which presented themselves to the fancy of Cicero, when he visited the walks of the Academy?

In the beginning of Descartes' dissertation upon *Method*, he has given a very interesting account of the pursuits which occupied his youth; and of the considerations which suggested to him the bold undertaking of reforming philosophy.

[3] Such too is the judgment pronounced by D'Alembert. "Les mathématiques dont Descartes semble avoir fait assez peu de cas, font neanmoins aujourd'hui la partie la plus solide et la moins contestée de sa gloire." To this he adds a very ingenious reflection on the comparative merits of Descartes, considered as a geometer and as a philosopher. "Comme philosophe, il a peut-être été aussi grand, mais il n'a pas été si heureux. La Géométrie, qui par la nature de son objet doit toujours gagner sans perdre, ne pouvoit manquer, étant maniée par un aussi grand génie, de faire des progrès très-sensibles et apparens pour tout le monde. La philosophie se trouvoit dans un état bien different, tout y étoit à commencer; *et que ne coûtent point les premiers pas en tout genre! le mérite de les faire dispense de celui d'en faire de grands.*" *Disc. Prel.*

which express notions too simple to admit of analysis. Mr Locke claims this improvement as entirely his own; but the merit of it unquestionably belongs to Descartes, although it must be owned that he has not always sufficiently attended to it in his own researches.[1]

2. His observations on the different classes of our prejudices;—particularly on the errors to which we are liable in consequence of a careless use of language as the instrument of thought. The greater part of these observations, if not the whole, had been previously hinted at by Bacon; but they are expressed by Descartes with greater precision and simplicity, and in a style better adapted to the taste of the present age.

3. The paramount and indisputable authority which, in all our reasonings concerning the human mind, he ascribes to the evidence of consciousness. Of this logical principle he has availed himself, with irresistible force, in refuting the scholastic sophisms against the liberty of human actions, drawn from the prescience of the Deity, and other considerations of a theological nature.

4. The most important, however, of all his improvements in metaphysics, is the distinction which he has so clearly and so strongly drawn between the *primary* and the *secondary* qualities of matter. This distinction was not unknown to some of the ancient schools of philosophy in Greece; but it was afterwards rejected by Aristotle, and by the schoolmen; and it was reserved for Descartes to place it in such a light, as (with the exception of a very few sceptical or rather paradoxical theorists) to unite the opinions of all succeeding inquirers. For this step, so apparently easy, but so momentous in its consequences, Descartes was not indebted to any long or difficult processes of reasoning; but to those habits of accurate and patient attention to the operations of his own mind, which, from his early years, it was the great business of his life to cultivate. It may be proper to add, that the epithets *primary* and *secondary*, now universally employed to mark the distinction in question, were first introduced by Locke; a circumstance which may have contributed to throw into the shade the merits of those inquirers who had previously struck into the same path.

As this last article of the Cartesian system has a close connection with several of the

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[1] "The names of simple ideas are not capable of any definitions; the names of all complex ideas are. It has not, that I know, been yet observed by anybody, what words are, and what are not capable of being defined." (Locke's *Essay*, Book iii. chap. iv. § iv.) Compare this with the *Principia* of Descartes, I. 10.; and with Lord Stair's *Philologia Nova Experimentalis*, pp. 9, and 79, printed at Leyden in 1686.

most refined conclusions yet formed concerning the intellectual phenomena, I feel it due to the memory of the author, to pause for a few moments, in order to vindicate his claim to some leading ideas, commonly supposed by the present race of metaphysicians to be of much later origin. In doing so, I shall have an opportunity, at the same time, of introducing one or two remarks, which, I trust, will be useful in clearing up the obscurity, which is allowed by some of the ablest followers of Descartes and Locke, still to hang over this curious discussion.

I have elsewhere observed, that Descartes has been very generally charged by the writers of the last century, with a sophistical play upon words in his doctrine concerning the non-existence of secondary qualities; while, in fact, he was the first person by whom the fallacy of this scholastic paralogism was exposed to the world.[1] In proof of this, it might be sufficient to refer to his own statement, in the first part of the *Principia*;[2] but, for a reason which will immediately appear, I think it more advisable, on this occasion, to borrow the words of one of his earliest and ablest commentators. "It is only (says Father Malebranche) since the time of Descartes, that to those confused and indeterminate questions, whether fire is hot, grass green, and sugar sweet, philosophers are in use to reply, by distinguishing the equivocal meaning of the words expressing sensible qualities. If by heat, cold, and savour, you understand such and such a disposition of parts, or some unknown motion of sensible qualities, then fire is hot, grass green, and sugar sweet. But if by heat and other qualities you understand what I feel by fire, what I see in grass, &c.

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1 "Descartes, Malebranche, and Locke, revived the distinction between primary and secondary qualities. But they made the secondary qualities mere sensations, and the primary ones resemblances of our sensations. They maintained that colour, sound, and heat, are not anything in bodies, but sensations of the mind.——— The paradoxes of these philosophers were only an abuse of words. For when they maintain, *as an important modern discovery*, that there is no heat in the fire, they mean no more than that the fire does not feel heat, which every one knew before."—*Reid's Inquiry*, chap. v. sect. viii.

2 See sections lxix, lxx, lxxi. The whole of these three paragraphs is highly interesting; but I shall only quote two sentences, which are fully sufficient to shew, that, in the above observations, I have done Descartes no more than strict justice.

"Patet itaque in re idem esse, cum dicimus nos percipere colores in objectis, ac si diceremus nos percipere aliquid in objectis, quod quidem quid sit ignoramus, sed a quo efficitur in nobis ipsis sensus quidam valde manifestus et perspicuus, qui vocatur sensus colorum.————Cum vero putamus nos percipere colores in objectis, etsi revera nesciamus quidnam sit quod tunc nomine coloris appellamus, nec ullam similitudinem intelligere possimus, inter colorem quem supponimus esse in objectis, et illum quem experimur esse in sensu, quia tamen hoc ipsum non advertimus, et multa alia sunt, ut magnitudo, figura, numerus, &c. quæ clare percipimus non aliter a nobis sentiri vel intelligi, quam ut sunt, aut saltem esse possunt in objectis, facile, in eum errorem delabimur, ut judicemus id, quod in objectis vocamus *colorem*, esse quid omnino simile colori quem sentimus, atque ita ut id quod nullo modo percipimus, a nobis clare percipi arbitraremur."

fire is not hot, nor grass green; for the heat I feel, and the colours I see, are only in the soul."[1] It is surprising how this, and other passages to the same purpose in Malebranche, should have escaped the notice of Dr Reid; for nothing more precise on the ambiguity in the names of secondary qualities is to be found in his own works. It is still more surprising that Buffier, who might be expected to have studied with care the speculations of his illustrious countrymen, should have directly charged, not only Descartes, but Malebranche, with maintaining a paradox, which they were at so much pains to banish from the schools of philosophy.[2]

The important observations of Descartes upon this subject, made their way into England very soon after his death. They are illustrated at considerable length, and with great ingenuity, by Glanville, in his *Scepsis Scientifica*, published about thirteen years before Malebranche's *Search after Truth*. So slow, however, is the progress of good sense, when it has to struggle against the prejudices of the learned, that, as lately as 1713, the paradox so clearly explained and refuted by Descartes, appears to have kept some footing in that university from which, about thirty years before, Mr Locke had been expelled. In a paper of *the Guardian*, giving an account of a visit paid by Jack Lizard to his mother and sisters, after a year and a half's residence at Oxford, the following *precis* is given of his logical attainments. "For the first week (it is said) Jack dealt wholly in paradoxes. It was a common jest with him to pinch one of his sister's lap-dogs, and afterwards prove he could not feel it. When the girls were sorting a set of knots, he would demonstrate to them that all the ribbons were of the same colour; or rather, says Jack, of no colour at all. My Lady Lizard herself, though she was not a little pleased with her son's improvements, was one day almost angry with him; for, having accidentally burnt her fingers as she was lighting the lamp for her tea-pot, in the midst of her anguish, Jack laid hold of the opportunity to instruct her, that there was no such thing as heat in the fire."

This miserable quibble about the non-existence of secondary qualities, never could have

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[1] *Recherche de la Vérité*, Livre vi. chap. ii.

[2] "J'ai admiré souvent que d'aussi grands hommes que Descartes et Malebranche, avec leurs sectateurs, fissent valoir, comme une rare découverte de leur philosophie, que *la chaleur étoit dans nous-mêmes et nullement dans le feu;* au lieu que le commun des hommes trouvoient que *la chaleur étoit dans le feu aussi bien que dans nous.*———Mais en ce fameux débat, de quoi s'agit il? Uniquement de l'imperfection du langage, qui causoit une idée confuse par le mot de *chaleur*, ce mot exprimant egalement deux choses, qui à la vérité ont quelque rapport ou analogie, et pourtant qui sont très differentes; savoir, 1. le sentiment de chaleur que nous éprouvons en nous; 2. la disposition qui est dans le feu à produire en nous ce sentiment de chaleur." *Cours de Sciences*, par le Père Buffier, p. 819. A Paris, 1732.

attracted the notice of so many profound thinkers, had it not been for a peculiar difficulty connected with our notions of *colour*, of which I do not know any one English philosopher who seems to have been sufficiently aware. That this quality belongs to the same class with sounds, smells, tastes, heat and cold, is equally admitted by the partizans of Descartes and of Locke; and must, indeed, appear an indisputable fact to all who are capable of reflecting accurately on the subject. But still, between *colour* and the other qualities now mentioned, a very important distinction must be allowed to exist. In the case of smells, tastes, sounds, heat and cold, every person must immediately perceive, that his senses give him only *a relative idea* of the external quality; in other words, that they only convey to him the knowledge of the existence of certain properties or powers in external objects, which fit them to produce certain sensations in his mind; and accordingly, nobody ever hesitated a moment about the truth of this part of the Cartesian philosophy, in so far as *these* qualities alone are concerned. But, in the application of the same doctrine to *colour*, I have conversed with many, with whom I found it quite in vain to argue; and *this*, not from any defect in their reasoning powers, but from their incapacity to reflect steadily on the subjects of their consciousness; or rather, perhaps, from their incapacity to separate, as objects of the understanding, two things indissolubly combined by early and constant habit, as objects of the imagination. The silence of modern metaphysicians on this head is the more surprising, that D'Alembert long ago invited their attention to it as one of the most wonderful phenomena in the history of the human mind. "The bias we acquire," I quote his own words, "in consequence of habits contracted in infancy, to refer to a substance material and divisible, what really belongs to a substance spiritual and simple, is a thing well worthy of the attention of metaphysicians. Nothing," he adds, "is perhaps more extraordinary, in the operations of the mind, than to see it transport its sensations out of itself, and to spread them, as it were, over a substance to which they cannot possibly belong." It would be difficult to state the fact in question in terms more brief, precise, and perspicuous.

That the illusion, so well described in the above quotation, was not overlooked by Descartes and Malebranche, appears unquestionably, from their extreme solicitude to reconcile it with that implicit faith, which, from religious considerations, they conceived to be due to the testimony of those faculties with which our Maker has endowed us. Malebranche, in particular, is at pains to distinguish between the sensation, and the judgment combined with it. "The sensation never deceives us; it differs in no respect from what we conceive it to be. The *judgment*, too, is natural, or rather (says Malebranche), *it is only a*

*sort of compounded sensation;*[1] but this judgment leads us into no error with respect to philosophical truth. The moment we exercise our reason, we see the fact in its true light, and can account completely for that illusive appearance which it presents to the imagination."

Not satisfied, however, with this solution of the difficulty, or rather perhaps apprehensive that it might not appear quite satisfactory to some others, he has called in to his assistance the doctrine of *original sin;* asserting, that all the mistaken judgments which our constitution leads us to form concerning external objects and their qualities, are the consequences of the fall of our first parents; since which *adventure* (as it is somewhat irreverently called by Dr Beattie), it requires the constant vigilance of reason to guard against the numberless tricks and impostures practised upon us by our external senses.[2] In another passage, Malebranche observes very beautifully (though not very consistently with his theological argument on the same point), that our senses being given us for the preservation of our bodies, it was requisite for our well-being, that we should judge as we do of sensible qualities. "In the case of the sensations of *pain* and of *heat*, it was much more advantageous that we should *seem* to feel them in those parts of the body which are immediately affected by them, than that we should associate them with the external objects by which they are occasioned; because pain and heat, having the power to injure our members, it was necessary that we should be warned in what place to apply the remedy; whereas *colours* not being likely, in ordinary cases, to hurt the eye, it would have been superfluous for us to know that they are painted on the *retina*. On the contrary, as they are only useful to us, from the information they convey with respect to things external, it was essential that we should be so formed as to attach them to the corresponding objects on which they depend.[3]

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[1] He would have expressed himself more accurately, if he had said, that the judgment is indissolubly combined with the sensation; but his meaning is sufficiently obvious.

[2] "We are informed by Father Malebranche, that the senses were at first as honest faculties as one could desire to be endued with, till after they were debauched by original sin; *an adventure* from which they contracted such an invincible propensity to cheating, that they are now continually lying in wait to deceive us." *Essay on Truth*, p. 241, second edition.

[3] *Recherche de la Verite*, Liv. i. chap. xiii. § 5. In Dr Reid's strictures on Descartes and Locke there are two remarks which I am at a loss how to reconcile. "Colour," says he, "differs from other secondary qualities in this, that whereas the name of the quality is sometimes given to the sensation which indicates it, and is occasioned by it, we never, as far as I can judge, give the name of *colour* to the sensation, but to the quality only." A few sentences before, he had observed, "That when we think or speak of any particular colour, however simple the notion may seem to be which is presented to the imagination, it is really in some sort compounded. It involves an unknown cause, and a known effect. The name of *colour* belongs indeed to the cause only, and not to the effect. But as the cause is unknown, we can form no distinct conception

The two following remarks, which I shall state with all possible brevity, appear to me to go far towards a solution of the problem proposed by D'Alembert.

1. According to the *new* theory of vision, *commonly* (but, as I shall afterwards shew, not altogether *justly*) ascribed to Dr Berkeley, lineal distance from the eye is not an original perception of sight. In the meantime, from the first moment that the eye opens, the most intimate connection must necessarily be established between the notion of *colour* and those of visible extension and figure. At first, it is not improbable that all of them may be conceived to be merely *modifications* of the mind; but, however this may be, the manifest consequence is, that when a comparison between the senses of Sight and of Touch has taught us to refer to a distance the objects of the one, the indissolubly associated sensations of the other must of course accompany them, how far soever that distance may extend.[1]

2. It is well known to be a general law of our constitution, when one thing is destined, either by nature or by convention, to be *the sign* of another, that the mind has a disposition to pass on, as rapidly as possible, to the thing signified, without dwelling on *the sign* as an object worthy of its attention. The most remarkable of all examples of this occurs in the acquired perceptions of sight, where our estimates of distance are frequently the result of an intellectual process, comparing a variety of different *signs* together, without a possibility on our part, the moment afterwards, of recalling one single step of the process to our recollection. Our inattention to the sensations of colour, considered as affections of the Mind, or as modifications of our own being, appears to me to be a fact of precisely the same description; for all these sensations were plainly intended by nature to perform the office of *signs*, indicating to us the figures and distances of things external. Of their essential importance in this point of view, an idea may be formed, by supposing for a moment the whole face of nature to exhibit only one uniform colour, without the slightest variety even of light and shade. Is it not self-evident that, on this supposition, the organ of sight would be entirely useless, inasmuch as it is by the *varieties* of colour alone that

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of it, but by its relation to the known effect. And, therefore, both go together in the imagination, and are so closely united, that they are mistaken for one simple object of thought." *Inquiry*, chap. vi. sect. 4.

These two passages, seem quite inconsistent with each other. If in the perception of colour, the sensation and the quality "be so closely united as to be mistaken for one single object of thought," does it not obviously follow, that it is to this compounded notion the name of *colour* must, in general, be given? On the other hand, when it is said *that the name of colour is never given to the sensation, but to the quality only*, does not this imply, that every time the word is pronounced, the quality is separated from the sensation, even in the imaginations of the vulgar?

[1] See Note M.

the outlines or visible figures of bodies are so defined, as to be distinguishable one from another? Nor could the eye, in this case, give us any information concerning diversities of *distance;* for all the various signs of it, enumerated by optical writers, presuppose the antecedent recognition of the bodies around us, as separate objects of perception. It is not therefore surprising, that *signs* so indispensably subservient to the exercise of our noblest sense, should cease, in early infancy, to attract notice as the subjects of our consciousness; and that afterwards they should present themselves to the imagination rather as qualities of Matter, than as attributes of Mind.[1]

To this reference of the sensation of colour to the external object, I can think of nothing so analogous as the feelings we experience in surveying a library of books. We speak of the volumes piled up on its shelves, as *treasures* or *magazines* of the knowledge of past ages; and contemplate them with gratitude and reverence, as inexhaustible *sources* of instruction and delight to the mind. Even in looking at a page of print or of manuscript, we are apt to say, that the ideas we acquire are received by the sense of sight; and we are scarcely conscious of a metaphor, when we employ this language. On such occasions we seldom recollect, that nothing is perceived by the eye but a multitude of *black strokes drawn upon white paper,* and that it is our own acquired habits which communicate to these *strokes* the whole of that significancy whereby they are distinguished from the unmeaning scrawling of an infant or a changeling. The knowledge which we conceive to be preserved in books, like the fragrance of a rose, or the gilding of the clouds, depends, for its existence, on the *relation* between the object and the percipient mind; and the only difference between the two cases is, that in the one, this relation is the local and temporary effect of conventional habits; in the other, it is the universal and the unchangeable work of nature. The art of printing, it is to be hoped, will in future render the former relation, as well as the latter, coëval with our species; but, in the past history of mankind, it is impossible to say how

[1] In Dr Reid's Inquiry, he has introduced a discussion concerning the perception of *visible figure,* which has puzzled me since the first time (more than forty years ago) that I read his work. The discussion relates to this question, Whether "there be any sensation proper to visible figure, by which it is suggested in vision?" The result of the argument is, that "our eye *might* have been so framed as to suggest the figure of the object, without suggesting colour, or any other quality; and, of consequence, that there seems to be *no sensation* appropriated to visible figure; this quality being suggested *immediately* by the material impression upon the organ, of which impression we are not conscious." (*Inquiry,* &c. chap. vi. sect. 8.) To my apprehension, nothing can appear more manifest than this, that, if there had been no *variety* in our sensations of colour, and still more, if we had had no sensation of colour whatsoever, the organ of sight could have given us no information, either with respect to *figures* or to *distances;* and, of consequence, would have been as useless to us, as if we had been afflicted, from the moment of our birth, with a *gutta serena.*

often it may have been dissolved. What vestiges can now be traced of those scientific attainments which, in early times, drew to *Egypt*, from every part of the civilized world, all those who were anxious to be initiated in the mysteries of philosophy? The symbols which still remain in that celebrated country, inscribed on eternal monuments, have long lost the correspondent *minds* which reflected upon them their own intellectual attributes. To us they are useless and silent, and serve only to attest the existence of arts, of which it is impossible to unriddle the nature and the objects.

> ———— Variis nunc sculpta figuris
> Marmora, trunca tamen visuntur mutaque nobis;
> Signa repertorum tuimur, cecidere reperta.

What has now been remarked with respect to *written characters*, may be extended very nearly to *oral language*. When we listen to the discourse of a public speaker, eloquence and persuasion seem to issue from his lips; and we are little aware, that we ourselves infuse the soul into every word that he utters. The case is exactly the same when we enjoy the conversation of a friend. We ascribe the charm entirely to his voice and accents; but without our co-operation, its potency would vanish. How very small the comparative proportion is, which, in such cases, the words spoken contribute to the intellectual and moral effect, I have elsewhere endeavoured to show.

I have enlarged on this part of the Cartesian system, *not* certainly on account of its intrinsic value, as connected with the theory of our external perceptions (although even in *this* respect of the deepest interest to every philosophical inquirer), but because it affords the most palpable and striking example I know of, to illustrate the indissoluble associations established during the period of infancy, between the intellectual and the material worlds. It was plainly the intention of nature, that our thoughts should be habitually directed to things external; and accordingly, the bulk of mankind are not only indisposed to study the intellectual phenomena, but are incapable of that degree of reflection which is necessary for their examination. Hence it is, that when we begin to analyze our own internal constitution, we find the facts it presents to us so very intimately combined in our conceptions with the qualities of matter, that it is impossible for us to draw distinctly and steadily the line between them; and that, when Mind and Matter are concerned in the same result, the former is either entirely overlooked, or is regarded only as an accessary principle, dependent for its existence on the latter. To the same cause it is owing, that we find it so difficult (if it be at all practicable) to form an idea of any of our intellectual operations, abstracted from *the images* suggested by their metaphorical names. It was objected to Descartes by some of his contemporaries, that the impossibility of accomplishing the *abstractions* which he recom-

mended, furnished of itself a strong argument against the soundness of his doctrines.[1] The proper answer to this objection does not seem to have occurred to him; nor, so far as I know, to any of his successors;—that the abstractions of the *understanding* are totally different from the abstractions of the *imagination;* and that we may *reason* with most logical correctness about things considered apart, which it is impossible, even in thought, to *conceive* as separated from each other. His own speculations concerning the indissolubility of the union established in the mind between the sensations of colour and the primary qualities of extension and figure, might have furnished him, on this occasion, with a triumphant reply to his adversaries; not to mention that the variety of metaphors, equally fitted to denote the same intellectual powers and operations, might have been urged as a demonstrative proof, that none of these metaphors have any connection with the general laws to which it is the business of the philosopher to trace the mental phenomena.

When Descartes established it as a general principle, that *nothing conceivable by the power of imagination, could throw any light on the operations of thought* (a principle which I consider as exclusively his own), he laid the foundation-stone of the Experimental Philosophy of the Human Mind. That the same truth had been previously perceived more or less distinctly, by Bacon and others, appears probable from the general complexion of their speculations; but which of them has expressed it with equal precision, or laid it down as a fundamental maxim in their logic? It is for this reason, that I am disposed to date the origin of the true Philosophy of Mind from the *Principia* of Descartes rather than from the *Organon* of Bacon, or the *Essay* of Locke; without, however, meaning to compare the French author with our two countrymen, either as a contributor to our stock of *facts* relating to the intellectual phenomena, or as the author of any important conclusion concerning the general laws to which they may be referred. It is mortifying to reflect on the inconceivably small number of subsequent inquirers by whom the spirit of this cardinal maxim has been fully seized; and that, even in our own times, the old and inveterate prejudice to which it is opposed, should not only have been revived with success, but should have been very generally regarded as an original and profound discovery in metaphysical science. These circumstances must plead my apology for the space I have assigned to the Cartesian Metaphysics in the crowded historical picture which I am at present attempting to sketch. The fulness of illustration which I have bestowed on the works of the master, will enable me to pass over those of his disciples, and even of his antagonists, with a correspondent brevity.[2]

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[1] See, in particular, *Gassendi Opera*, Tom. III. pp. 300, 301. Lugduni, 1658.

[2] The Cartesian doctrine concerning the secondary qualities of matter, is susceptible of various other im-

After having said so much of the singular merits of Descartes as the father of genuine metaphysics, it is incumbent on me to add, that his errors in this science were on a scale of proportionate magnitude. Of these the most prominent (for I must content myself with barely mentioning a few of essential importance) were his obstinate rejection of all speculations about final causes; [1] his hypothesis concerning the lower animals, which he considered as mere machines; [2] his doctrine of *innate* ideas, *as understood and expounded by himself*; [3] his noted paradox of placing the *essence* of mind in thinking, and of matter in extension; [4] and his new modification of the ideal theory of perception, adopted afterwards, with some very slight changes, by Malebranche, Locke, Berkeley, and Hume. [5] To some of these errors I shall have occasion to refer in the sequel of this Discourse. The foregoing slight enumeration is sufficient for my present purpose.

In what I have hitherto said of Descartes, I have taken no notice of his metaphysico-

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portant applications. Might it not be employed, at least as an *argumentum ad hominem* against Mr Hume and others, who, admitting *this* part of the Cartesian system, seem nevertheless to have a secret leaning to the scheme of materialism? Mr Hume has somewhere spoken of *that little agitation of the brain we call thought*. If it be unphilosophical to confound our *sensations* of colour, of heat, and of cold, with such qualities of extension, figure, and solidity, is it not, if possible, still more so, to confound with these qualities the phenomena of thought, of volition, and of moral emotion?

[1] It is not unworthy of notice, that, in spite of his own logical rules, Descartes sometimes seems insensibly to adopt, on this subject, the common ideas and feelings of mankind. Several instances of this occur in his treatise on the Passions, where he offers various conjectures concerning the *uses* to which they are subservient. The following sentence is more peculiarly remarkable: "Mihi persuadere nequeo, naturam indedisse hominibus ullum affectum qui semper visiosus sit, nullumque usum bonum et laudabile habeat." Art. clxxv.

[2] This hypothesis never gained much ground in England; and yet a late writer of distinguished eminence in *some* branches of science, has plainly intimated that, in his opinion, the balance of probabilities inclined in its favour. "I omit mentioning other animals here," says Mr Kirwan in his *Metaphysical Essays*, "*as it is at least doubtful whether they are not mere automatons.*" *Met. Essays*, p. 41. Lond. 1809.

[3] I have added the clause in *Italics*, because, in Descartes' reasonings on this question, there is no inconsiderable portion of most important truth, debased by a large and manifest alloy of error.

[4] To this paradox may be traced many of the conclusions of the author, both on physical and on metaphysical subjects. One of the most characteristical features, indeed, of his genius, is the mathematical concatenation of his opinions, even on questions which, at first sight, seem the most remote from each other; a circumstance which, when combined with the extraordinary perspicuity of his style, completely accounts for the strong hold his philosophy took of every mind, thoroughly initiated, at an early period of life, in its principles and doctrines. In consequence of conceiving the essence of matter to consist in extension, he was necessarily obliged to maintain the doctrine of a universal *plenum*; upon which doctrine the theory of the vortices came to be grafted by a very short and easy process. The same idea forced him, at the very outset of his *Metaphysical Meditations*, to assert, much more dogmatically than his premises seem to warrant, the *non-extension* of Mind; and led him on many occasions to blend, very illogically, this *comparatively* disputable dogma, with the facts he has to state concerning the mental phenomena.

[5] See Note N.

physiological theories relative to the connection between soul and body. Of these theories, however, groundless and puerile as they are, it is necessary for me, before I proceed farther, to say a few words, on account of their extensive and lasting influence on the subsequent history of the science of Mind, not only upon the Continent, but in our own Island.

The hypothesis of Descartes, which assigns to the soul for its principal seat the *pineal gland* or *conarion*, is known to every one who has perused the *Alma* of Prior. It is not, perhaps, equally known, that the circumstance which determined him to fix on this particular spot, was the very plausible consideration, that, among the different parts of the brain, *this* was the only one he could find, which, being single and central, was fitted for the habitation of a being, of which he conceived unity and indivisibility to be essential and obvious attributes.[1] In what manner the *animal spirits*, by their motions forwards and backwards in the nervous tubes, keep up the communication between this gland and the different parts of the body, so as to produce the phenomena of perception, memory, imagination, and muscular motion, he has attempted particularly to explain; describing the processes by which these various effects are accomplished, with as decisive a tone of authority, as if he had been demonstrating experimentally the circulation of the blood. How curious to meet with such speculations in the works of the same philosopher, who had so clearly perceived the necessity, in studying the laws of Mind, of abstracting entirely from the analogies of Matter; and who, at the outset of his inquiries, had carried his scepticism so far, as to require a proof even of the existence of his own body! To those, however, who reflect with attention on the *method* adopted by Descartes, this inconsistency will not appear so inexplicable as at first sight may be imagined; inasmuch as the same scepticism which led him to suspend his faith in his intellectual faculties till he had once proved to his satisfaction, from the necessary veracity of God, that these faculties were to be regarded as the divine oracles, prepared him, in all the subsequent steps of his progress, to listen to the suggestions of his own fallible judgment, with more than common credulity and confidence.

The ideas of Descartes, respecting the communication between soul and body, are now so universally rejected, that I should not have alluded to them here, had it not been for their manifest influence in producing, at the distance of a century, the rival hypothesis of Dr Hartley. The first traces of this hypothesis occur in some *queries* of Sir Isaac Newton, which he was probably induced to propose, less from the conviction of his own mind, than from a wish to turn the attention of philosophers to an examination of the correspondent part of the Cartesian system. Not that I would be understood to deny

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[1] See in particular, the *Treatise de Passionibus*, Art. 31, 32. See also Note O.

that this great man seems, on more than one occasion, to have been so far misled by the example of his predecessor, as to indulge himself in speculating on questions altogether unsusceptible of solution. In the present instance, however, there cannot, I apprehend, be a doubt, that it was the application made by Descartes of the old theory of *animal spirits*, to explain the mental phenomena, which led Newton into that train of thinking which served as the ground-work of Hartley's Theory of *Vibrations.* [1]

It would be useless to dwell longer on the reveries of a philosopher, much better known to the learned of the present age by the boldness of his exploded errors, than by the profound and important truths contained in his works. At the period when he appeared, it may perhaps be questioned, Whether the truths which he taught, or the errors into which

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[1] The physiological theory of Descartes, concerning the connection between soul and body, was adopted, together with some of his sounder opinions, by a contemporary English philosopher, Mr Smith of Cambridge, whom I had occasion to mention in a former note; and that, for some time after the beginning of the eighteenth century, it continued to afford one of the chief subjects of controversy between the two English universities, the *Alma* of Prior affords incontestible evidence. From the same poem it appears, how much the reveries of Descartes about the *seat of the soul*, contributed to wean *the wits of Cambridge* from their former attachment to the still more incomprehensible pneumatology of the schoolmen.

——————Here Matthew said,
Alma in verse, in prose the mind
By Aristotle's pen defin'd,
Throughout the body squat or tall,
Is, *bona fide*, all in all.
And yet, slap-dash, is all again
In every sinew, nerve, and vein;
Runs here and there like Hamlet's Ghost,
While everywhere she rules the roast.
This system, Richard, we are told,
The men of Oxford firmly hold;
The Cambridge wits, you know, deny
With *ipse dixit* to comply.
They say (for in good truth they speak
With small respect of that old Greek)
That, putting all his words together,
'Tis three blue beans in one blue bladder.
Alma, they strenuously maintain,
Sits cock-horse on her throne the brain,
And from that seat of thought dispenses
Her sovereign pleasure to the senses, &c. &c.

The whole poem, from beginning to end, is one continued piece of ridicule upon the various hypotheses of physiologists concerning the nature of the communication between soul and body. The amusing contrast between the solemn absurdity of these disputes, and the light pleasantry of the excursions to which they lead the fancy of the poet, constitutes the principal charm of this performance; by far the most original and characteristical of all Prior's Works.

he fell, were most instructive to the world. The controversies provoked by the latter had certainly a more immediate and palpable effect in awakening a general spirit of free inquiry. To this consideration may be added an ingenious and not altogether unsound remark of D'Alembert, that "when absurd opinions are become inveterate, it is sometimes necessary to replace them by other errors, if nothing better can be done. Such (he continues) are the uncertainty and the vanity of the human mind, that it has always need of *an opinion* on which it may lean; it is a child to whom a play-thing must occasionally be presented in order to get out of its hands a mischievous weapon: the play-thing will soon be abandoned, when the light of reason begins to dawn."[1]

Among the opponents of Descartes, Gassendi was one of the earliest, and by far the most formidable. No two philosophers were ever more strongly contrasted, both in point of talents and of temper; the former as far superior to the latter in originality of genius—in powers of concentrated attention to the phenomena of the internal world—in classical taste—in moral sensibility, and in all the rarer gifts of the mind; as he fell short of him in erudition—in industry as a book-maker—in the justness of his logical views, so far as the phenomena of the *material* universe are concerned—and, in general, in those literary qualities and attainments, of which the bulk of mankind either are, or think themselves best qualified to form an estimate. The reputation of Gassendi, accordingly, seems to have been at its height in his own lifetime; that of Descartes made but little progress, till a considerable time after his death.

The comparative justness of Gassendi's views in natural philosophy, may be partly, perhaps chiefly, ascribed to his diligent study of Bacon's works; which Descartes (if he ever read them), has nowhere alluded to in his writings. This extraordinary circumstance in the character of Descartes, is the more unaccountable, that not only Gassendi, but some of his other correspondents, repeatedly speak of Bacon in terms which one should think could scarcely have failed to induce him to satisfy his own mind whether their encomiums were well or ill founded. One of these, while he contents himself, from very obvious feelings of delicacy, with mentioning the Chancellor of England, as the person who, *before the time of Descartes*, had entertained the justest notions about the method of prosecuting physical inquiries, takes occasion, in the same letter, to present him, in the form of a friendly admonition from himself, with the following admirable summary of the *instauratio magna*. "To all this it must be added, that no architect, however skilful, can raise an edifice, unless he

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[1] See Note P.

be provided with proper materials. In like manner, your *method*, supposing it to be perfect, can never advance you a single step in the explanation of natural causes, unless you are in possession of the facts necessary for determining their effects. They who, without stirring from their libraries, attempt to discourse concerning the works of nature, may indeed tell us what sort of world they would have made, if God had committed that task to their ingenuity; but, without a wisdom truly divine, it is impossible for them to form an idea of the universe, at all approaching to that in the mind of its Creator. And, although your *method* promises everything that can be expected from human genius, it does not, therefore, lay any claim to the art of divination; but only boasts of deducing from the assumed *data*, all the truths which follow from them as legitimate consequences; which *data*, can, in physics, be nothing else but principles previously established by experiment."[1] In Gassendi's controversies with Descartes, the name of Bacon seems to be studiously introduced on various occasions, in a manner still better calculated to excite the curiosity of his antagonist; and in his historical review of logical systems, the *heroical attempt which gave birth to the Novum Organon* is made the subject of a separate chapter, immediately preceding that which relates to the *Metaphysical Meditations* of Descartes.

The partiality of Gassendi for the Epicurean physics, if not originally imbibed from Bacon, must have been powerfully encouraged by the favourable terms in which he always mentions the Atomic or Corpuscular theory. In its conformity to that luminous simplicity which everywhere characterizes the operations of nature, this theory certainly possesses a decided superiority over all the other conjectures of the ancient philosophers concerning the material universe; and it reflects no small honour on the sagacity both of Bacon and of Gassendi, to have perceived so clearly the strong analogical presumption which this conformity afforded in its favour, prior to the unexpected lustre thrown upon it by the researches of the Newtonian school. With all his admiration, however, of the Epicurean physics, Bacon nowhere shews the slightest leaning towards the metaphysical or ethical doctrines of the same sect; but, on the contrary, considered (and, I apprehend, rightly considered) the atomic theory as incomparably more hostile to atheism, than the hypothesis of four mutable elements, and of one immutable fifth essence. In this last opinion, there is every reason to believe that Gassendi fully concurred; more especially, as he was a zealous advocate for the investigation of *final causes*, even in inquiries strictly physical. At the same time, it cannot be denied, that, on many questions, both of Meta-

[1] See the first Epistle to Descartes, prefixed to his *Treatise on the Passions*. Amstel. 1664.

physics and of Ethics, this very learned theologian (one of the most orthodox, *professedly*, of whom the Catholic church has to boast), carried his veneration for the authority of Epicurus to a degree bordering on weakness and servility; and although, on such occasions, he is at the utmost pains to guard his readers against the dangerous conclusions commonly ascribed to his master, he has nevertheless retained more than enough of his system to give a plausible colour to a very general suspicion, that he secretly adopted more of it than he chose to avow.

As Gassendi's attachment to the physical doctrines of Epicurus, predisposed him to give an easier reception than he might otherwise have done to his opinions in Metaphysics and in Ethics, so his unqualified contempt for the hypothesis of the Vortices, seems to have created in his mind an undue prejudice against the speculations of Descartes on all other subjects. His objections to the argument by which Descartes has so triumphantly established the distinction between Mind and Matter, as separate and heterogeneous objects of human knowledge, must now appear, to every person capable of forming a judgment upon the question, altogether frivolous and puerile; amounting to nothing more than this, that all our knowledge is received by the channel of the external senses,—insomuch, that there is not a single object of the understanding which may not be ultimately analyzed into *sensible images;* and of consequence, that when Descartes proposed to abstract from these images in studying the mind, he rejected the only materials out of which it is possible for our faculties to rear any superstructure. The sum of the whole matter is (to use his own language), that "there is no real distinction between *imagination* and *intellection;*" meaning, by the former of these words, the power which the mind possesses of *representing* to itself the material objects and qualities it has previously perceived. It is evident, that this conclusion coincides exactly with the tenets inculcated in England at the same period by his friend Hobbes,[1] as well as with those revived at a latter period by Diderot, Horne Tooke, and many other writers, both French and English, who, while they were only repeating the exploded dogmas of Epicurus, fancied they were pursuing, with miraculous success, the new path struck out by the genius of Locke.

It is worthy of remark, that the argument employed by Gassendi against Descartes, is copied almost *verbatim* from his own version of the account given by *Diogenes Laertius*

[1] The affection of Gassendi for Hobbes, and his esteem for his writings, are mentioned in very strong terms by Sorbière. "Thomas Hobbius Gassendo charissimus, cujus libellum *De Corpore* paucis ante obitum mensibus accipiens, osculatus est subjungens, *mole quidem parvus est iste liber, verùm totus, ut opinor, medullâ scatet!*" (Sorberii *Pref.*) Gassendi's admiration of Hobbes' Treatise *De Cive*, was equally warm; as we learn from a letter of his to Sorbière, prefixed to that work.

of the sources of our knowledge, according to the principles of the Epicurean philosophy;[1]—so very little is there of novelty in the consequences deduced by modern materialists from the scholastic proposition, *Nihil est in intellectu quod non fuit prius in sensu.* The same doctrine is very concisely and explicitly stated in a maxim formerly quoted from Montaigne, that "the senses are the *beginning* and *end* of all our knowledge;"—a maxim which Montaigne learned from his oracle Raymond de Sebonde;—which, by the present race of French philosophers, is almost universally supposed to be sanctioned by the authority of Locke;—and which, if true, would at once cut up by the roots, not only all metaphysics, but all ethics, and all religion, both natural and revealed. It is accordingly with this very maxim that Madame du Deffand (in a letter which rivals anything that the fancy of Moliere has conceived in his *Femmes Savantes)* assails Voltaire for his imbecility in attempting a reply to an atheistical book then recently published. In justice to this celebrated lady, I shall transcribe part of it in her own words, as a precious and authentic document of the philosophical tone affected by the higher orders in France, during the reign of Louis XV.

"J'entends parler d'une refutation d'un certain livre, (*Systême de la Nature.)* Je voudrois l'avoir. Je m'en tiens à connoître ce livre par vous. Toutes refutations de systême doivent être bonnes, surtout quand c'est vous qui les faites. Mais, mon cher Voltaire, ne vous ennuyez-vous pas de tous les raisonnemens métaphysiques sur les matières inintelligibles. *Peut-on donner des idées, ou peut-on en admettre d'autres que celles que nous reçevons par nos sens?"*—If the Senses be *the beginning* and *end* of all our knowledge, the inference here pointed at is quite irresistible.[2]

A learned and profound writer has lately complained of the injustice done by the present age to Gassendi; in whose works, he asserts, may be found the whole of the doctrine commonly ascribed to Locke concerning the origin of our knowledge.[3] The re-

[1] Compare *Gassendi Opera,* Tom. III. p. 300, 301; and Tom. V. p. 12.

[2] Notwithstanding the evidence (according to *my* judgment) of this conclusion, I trust it will not be supposed that I impute the slightest bias in its favour to the generality of those who have adopted the premises. If an author is to be held chargeable with all the consequences logically deducible from his opinions, who can hope to escape censure? And, in the present instance, how few are there among Montaigne's disciples, who have ever reflected for a moment on the real meaning and import of the proverbial maxim in question!

[3] "Gassendi fut le premier auteur de la nouvelle philosophie de l'esprit humain; car il est tems de lui rendre, à cet égard, une justice qu'il n'a presque jamais obtenue de ses propres compatriotes. Il est très singulier en effet, qu'en parlant de la nouvelle philosophie de l'esprit humain, nous disions toujours, *la philosophie de Locke.* D'Alembert et Condillac ont autorisé cette expression, en rapportant l'un et l'autre à Locke exclusivement, la gloire de cette invention," &c. &c. *De Gerando, Hist. Comp. des Systêmes,* Tome I. p. 301.

mark is certainly just, if restricted to Locke's doctrine as interpreted by the greater part of philosophers on the Continent; but it is very wide of the truth, if applied to it as now explained and modified by the most intelligent of his disciples in this country. The main scope, indeed, of Gassendi's argument against Descartes, is to materialize that class of our ideas which the Lockists as well as the Cartesians consider as the exclusive objects of the power of *reflection;* and to shew that these ideas are all ultimately resolvable into images or conceptions borrowed from things external. It is not, therefore, what is sound and valuable in this part of Locke's system, but the errors grafted on it in the comments of some of his followers, that can justly be said to have been borrowed from Gassendi. Nor has Gassendi the merit of originality, even in these errors; for scarcely a remark on the subject occurs in his works, but what is copied from the accounts transmitted to us of the Epicurean metaphysics.

Unfortunately for Descartes, while he so clearly perceived that the origin of those ideas which are the most interesting to human happiness, could not be traced to our external senses, he had the weakness, instead of stating this fundamental proposition in plain and precise terms, to attempt an explanation of it by the extravagant hypothesis of *innate ideas.* This hypothesis gave Gassendi great advantages over him, in the management of their controversy; while the subsequent adoption of Gassendi's reasonings against it by Locke, has led to a very general but ill-founded belief, that the latter, as well as the former, rejected, along with the doctrine of *innate ideas,* the various important and well-ascertained truths combined with it in the Cartesian system.

The hypothetical language afterwards introduced by Leibnitz concerning the human soul (which he sometimes calls a *living mirror of the universe,* and sometimes supposes to contain within itself *the seeds* of that knowledge which is gradually unfolded in the progressive exercise of its faculties), is another impotent attempt to explain a mystery unfathomable by human reason. The same remark may be extended to some of Plato's reveries on this question, more particularly to his supposition, that those ideas which cannot be traced to any of our external senses, were acquired by the soul in its state of pre-existence. In all of these theories, as well as in that of Descartes, the cardinal truth is assumed as indisputable, that the Senses *are not* the only sources of human knowledge; nor is anything wanting to render them correctly logical, but the statement of this truth as an ultimate fact (or at least as a fact hitherto unexplained) in our intellectual frame.

It is very justly observed by Mr Hume, with respect to Sir Isaac Newton, that "while he seemed to draw off the veil from some of the mysteries of nature, he showed, at the same time, the imperfections of the mechanical philosophy, and thereby restored her ultimate se-

crets to that obscurity in which they ever did, and ever will remain."[1] When the justness of this remark shall be as universally acknowledged in the science of Mind as it now is in Natural Philosophy, we may reasonably expect that an end will be put to those idle controversies which have so long diverted the attention of metaphysicians from the proper objects of their studies.

The text of Scripture, prefixed by Dr Reid as a motto to his *Inquiry*, conveys, in a few words, the result of his own modest and truly philosophical speculations on the origin of our knowledge, and expresses this result in terms strictly analogous to those in which Newton speaks of the law of gravitation :—" *The inspiration of the Almighty hath given them understanding.*" Let our researches concerning the development of the Mind, and the *occasions* on which its various notions are first formed, be carried back ever so far towards the commencement of its history, in *this* humble confession of human ignorance they must terminate at last.

I have dwelt thus long on the writings of Gassendi, much less from my own idea of their merits, than out of respect to an author, in whose footsteps Locke has frequently condescended to tread. The epigrammatic encomium bestowed on him by Gibbon, who calls him " le meilleur philosophe des litterateurs, et le meilleur litterateur des philosophes," appears to me quite extravagant.[2] His learning, indeed, was at once vast and accurate ; and, as a philosopher, he is justly entitled to the praise of being one of the first who entered thoroughly into the spirit of the Baconian logic. But his inventive powers, which were probably not of the highest order, seem to have been either dissipated amidst the multiplicity of his literary pursuits, or laid asleep by his indefatigable labours, as a Commentator and a Compiler. From a writer of this class, new lights were not to be expected in the study of the human Mind ; and accordingly, *here* he has done little or nothing, but to revive and to repeat over the doctrines of the old Epicureans. His works amount to six large volumes in folio ; but the substance of them might be compressed into a much smaller compass, without any diminution of their value.

In *one* respect Gassendi had certainly a great advantage over his antagonist—the good humour which never forsook him in the heat of a philosophical argument. The comparative indifference with which he regarded most of the points at issue between them, was perhaps the chief cause of that command of temper so uniformly displayed in all his controver-

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[1] *History of Great Britain*, chap. lxxi.

[2] *Essai sur l'Etude de la Litterature.*

sies, and so remarkably contrasted with the constitutional irritability of Descartes. Even the faith of Gassendi in his own favourite master, Epicurus, does not seem to have been very strong or dogmatical, if it be true that he was accustomed to allege, as the chief ground of his preferring the Epicurean physics to the theory of the Vortices, "that chimera for chimera, he could not help feeling some partiality for that which was two thousand years older than the other." [1]

About twenty years after the death of Gassendi (who did not long survive Descartes), Malebranche entered upon his philosophical career. The earlier part of his life had, by the advice of some of his preceptors, been devoted to the study of ecclesiastical history, and of the learned languages; for neither of which pursuits does he seem to have felt that marked predilection which afforded any promise of future eminence. At length, in the twenty-fifth year of his age, he accidentally met with Descartes' *Treatise on Man*, which opened to him at once a new world, and awakened him to a consciousness of powers, till then unsuspected either by himself or by others. Fontenelle has given a lively picture of the enthusiastic ardour with which Malebranche first read this performance; and describes its effects on his nervous system as sometimes so great, that he was forced to lay aside the book till the palpitation of his heart had subsided.

It was only ten years after this occurrence when he published *The Search after Truth*; a work which, whatever judgment may now be passed on its philosophical merits, will always form an interesting study to readers of taste, and a useful one to students of human nature. Few books can be mentioned, combining, in so great a degree, the utmost depth and abstraction of thought, with the most pleasing sallies of imagination and eloquence; and none, where they who delight in the observation of intellectual character may find more ample illustrations, both of the strength and weakness of the human understanding. It is a singular feature in the history of Malebranche, that, notwithstanding the poetical colouring which adds so much animation and grace to his style, he never could read, without disgust, a page of the finest verses; [2] and that, although Imagination was manifestly the predominant ingredient in the composition of his own genius, the most elaborate passages in his works are those where he inveighs against this treacherous faculty, as the prolific parent of our most fatal delusions. [3]

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[1] See Note Q.

[2] Bayle.—Fontenelle.—D'Alembert.

[3] In one of his arguments on this head, Malebranche refers to the remarks previously made on the same subject by an English philosopher, who, like himself, has more than once taken occasion, while warning his

In addition to the errors, more or less incident to all men, from the unresisted sway of imagination during the infancy of reason, Malebranche had, in his own case, to struggle with all the prejudices connected with the peculiar dogmas of the Roman Catholic faith. Unfortunately, too, he everywhere discovers a strong disposition to blend his theology and his metaphysics together; availing himself of the one as an auxiliary to the other, wherever, in either science, his ingenuity fails him in establishing a favourite conclusion. To this cause is chiefly to be ascribed the little attention now paid to a writer formerly so universally admired, and, in point of fact, the indisputable author of some of the most refined speculations claimed by the theorists of the eighteenth century. As for those mystical controversies about *Grace* with Anthony Arnauld, on which he wasted so much of his genius, they have long sunk into utter oblivion; nor should I have here revived the recollection of them, were it not for the authentic record they furnish of the passive bondage in which, little more than a hundred years ago, two of the most powerful minds of that memorable period were held by a creed, renounced, at the Reformation, by all the Protestant countries of Europe; and the fruitful source, wherever it has been retained, of other prejudices, not less to be lamented, of an opposite description.[1]

When Malebranche touches on questions not positively decided by the church, he exhibits a remarkable boldness and freedom of inquiry; setting at nought those human authorities which have so much weight with men of unenlightened erudition; and sturdily opposing his own reason to the most inveterate prejudices of his age. His disbelief in the

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readers against the undue influence of imagination over the judgment, to exemplify the boundless fertility and originality of his own. The following allusion of Bacon's, quoted by Malebranche, is eminently apposite and happy: "Omnes perceptiones tam sensus quam mentis sunt ex analogia hominis, non ex analogia universi: Estque intellectus humanus instar speculi inæqualis ad radios rerum, qui suam naturam naturæ rerum immiscet, eamque distorquet et inficit."

[1] Of this disposition to blend theological dogmas with philosophical discussions, Malebranche was so little conscious in himself, that he has seriously warned his readers against it, by quoting an aphorism of Bacon's, peculiarily applicable to his own writings: "Ex divinorum et humanorum malesana admixtione non solum educitur philosophia phantastica, sed etiam religio hæretica. Itaque salutare admodum est si mente sobria fidei tantum dentur quæ fidei sunt." In transcribing these words, it is amusing to observe, that Malebranche has slily suppressed the name of the author from whom they are borrowed; manifestly from an unwillingness to weaken their effect, by the suspicious authority of a philosopher not in communion with the Church of Rome. *Recherche de la Vérité,* Liv. ii. chap. ix.

Dr Reid, proceeding on the supposition that Malebranche was a Jesuit, has ascribed to the antipathy between this order and the Jansenists, the warmth displayed on both sides, in his disputes with Arnauld (*Essays on the Int. Powers*, p. 124); but the fact is, that Malebranche belonged to the Congregation of the *Oratory;* a society much more nearly allied to the Jansenists than to the Jesuits; and honourably distinguished, since its first origin, by the moderation as well as learning of its members.

reality of sorcery, which, although cautiously expressed, seems to have been complete, affords a decisive proof of the soundness of his judgment, where he conceived himself to have any latitude in exercising it. The following sentences contain more good sense on the subject, than I recollect in any contemporary author. I shall quote them, as well as the other passages I may afterwards extract from his writings, in his own words, to which it is seldom possible to do justice in an English version.

"Les hommes même les plus sages se conduisent plutôt par l'imagination des autres, je veux dire par l'opinion et par la coûtume, que par les regles de la raison. Ainsi dans les lieux où l'on brule les sorciers, on ne voit autre chose, parce que dans les lieux où l'on les condamne au feu, on croit veritablement qu'ils le sont, et cette croyance se fortifie par les discours qu'on en tient. Que l'on cesse de les punir et qu'on les traite comme des fous, et l'on verra qu'avec le tems ils ne seront plus sorciers; parce que ceux qui ne le sont que par imagination, qui font certainement le plus grand nombre, deviendront comme les autres hommes.

"C'est donc avec raison que plusieurs Parlemens ne punissent point les sorcièrs : ils s'en trouve beaucoup moins dans les terres de leur ressort : Et l'envie, la haine, et la malice des méchans ne peuvent se servir de ce prétexte pour accabler les innocens."

How strikingly has the sagacity of these anticipations and reflections been verified, by the subsequent history of this popular superstition in our own country, and indeed in every other instance where the experiment recommended by Malebranche has been tried! Of this sagacity much must, no doubt, be ascribed to the native vigour of a mind struggling against and controlling early prejudices; but it must not be forgotten, that, notwithstanding his retired and monastic life, Malebranche had breathed the same air with the associates and friends of Descartes and of Gassendi; and that no philosopher seems ever to have been more deeply impressed with the truth of that golden maxim of Montaigne—"Il est bon de frotter et limer notre cervelle contre celle d'autrui."

Another feature in the intellectual character of Malebranche, presenting an unexpected contrast to his powers of abstract meditation, is the attentive and discriminating eye with which he appears to have surveyed the habits and manners of the comparatively little circle around him; and the delicate yet expressive touches with which he has marked and defined some of the nicestshades and varieties of genius. [1] To this branch of the Philosophy of Mind, not certainly the least important and interesting, he has contributed a greater num-

[1] See among other passages, *Rech. de la Vérité*, Liv. ii. chap. ix.

ber of original remarks than Locke himself;[1]—since whose time, with the single exception of Helvetius, hardly any attention has been paid to it, either by French or English metaphysicians. The same practical knowledge of the human understanding, modified and diversified, as we everywhere see it, by education and external circumstances, is occasionally discovered by his very able antagonist Arnauld; affording, in both cases, a satisfactory proof, that the narrowest field of experience may disclose to a superior mind those refined and comprehensive results, which common observers are forced to collect from an extensive and varied commerce with the world.

In some of Malebranche's incidental strictures on men and manners, there is a lightness of style and fineness of *tact*, which one would scarcely have expected from the mystical divine, who believed that *he saw all things in God.* Who would suppose that the following paragraph forms part of a profound argument on the influence of the external senses over the human intellect?

" Si par exemple, celui qui parle s'énonce avec facilité, s'il garde une mesure agréable

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[1] In one of Locke's most noted remarks of this sort, he has been anticipated by Malebranche, on whose clear yet concise statement, he does not seem to have thrown much new light by his very diffuse and wordy commentary. " If in having our ideas in the memory ready at hand, consists quickness of parts; in this of having them unconfused, and being able nicely to distinguish one thing from another, where there is but the least difference, consists, in a great measure, the exactness of judgment and clearness of reason, which is to be observed in one man above another. And hence, perhaps, may be given some reason of that common observation, that men who have a great deal of wit, and prompt memories, have not always the clearest judgment, or deepest reason. For Wit, lying most in the assemblage of ideas, and putting those together with quickness and variety, *wherein* can be found any resemblance or congruity, *thereby* to make up pleasant pictures, and agreeable visions in the fancy; Judgment, on the contrary, lies quite on the other side, in separating carefully, one from another, ideas *wherein* can be found the least difference, *thereby* to avoid being misled by similitude, and by affinity to take one thing for another." *Essay, &c.* B. ii. c. xi. § 2.

" Il y a donc des esprits de deux sortes. Les uns remarquent aisément les différences des choses, et ce sont les bons esprits. Les autres imaginent et supposent de la ressemblance entr'elles, et ce sont les esprits superficiels." *Rech. de la Vérité.* Liv. ii. *Seconde Partie*, chap. ix.

At a still earlier period, Bacon had pointed out the same cardinal distinction in the intellectual characters of individuals.

" Maximum et velut radicale discrimen ingeniorum, quoad philosophiam et scientias, illud est; quod alia ingenia sint fortiora et aptiora ad notandas rerum differentias; alia, ad notandas rerum similitudines. Ingenia enim constantia et acuta, figere contemplationes, et morari, et hærere in omni subtilitate differentiarum possunt. Ingenia autem sublimia, et discursiva, etiam tenuissimas et catholicas rerum similitudines et cognoscunt, et componunt. Utrumque autem ingenium facile labitur in excessum, prensando aut gradus rerum, aut umbras."

*That strain I heard was of a higher mood!* It is evident, that Bacon has here seized, in its most general form, the very important truth perceived by his two ingenious successors in particular cases. *Wit*, which Locke contrasts with *judgment*, is only one of the various talents connected with what Bacon calls the *discursive genius;* and indeed, a talent very subordinate in dignity to most of the others.

dans ses périodes, s'il a l'air d'un honnête homme et d'un homme d'esprit, si c'est une personne de qualité, s'il est suivi d'un grand train, s'il parle avec autorité et avec gravité, si les autres l'écoutent avec respect et en silence, s'il a quelque réputation, et quelque commerce avec les esprits du premier ordre, enfin, s'il est assez heureux pour plaire, ou pour être estimé, il aura raison dans tout ce qu'il avancera; et il n'y aura pas jusqu'à son collet et à ses manchettes, qui ne prouvent quelque chose." [1]

In his philosophical capacity, Malebranche is to be considered in two points of view: 1. As a commentator on Descartes; and, 2. As the author of some conclusions from the Cartesian principles, not perceived or not avowed by his predecessors of the same school.

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[1] I shall indulge myself only in one other citation from Malebranche, which I select partly on account of the curious extract it contains from an English publication long since forgotten in this country; and partly as a proof that this learned and pious father was not altogether insensible to the ludicrous.

"Un illustre entre les Sçavans, qui a fondé des chaires de Géometrie et d'Astronomie dans l'Université d'Oxford,[1] commençe un livre, qu'il s'est avisé de faire sur les huit premières propositions d'Euclide, par ces paroles. *Consilium meum est, auditores, si vires et valetudo suffecerint, explicare definitiones, petitiones, communes sententias, et octo priores propositiones primi libri elementorum, cætera post me venientibus relinquere:* et il le finit par celles-ci: *Exsolvi per Dei gratiam, Domini auditores, promissum, liberavi fidem meam, explicavi pro modulo meo definitiones, petitiones, communes sententias, et octo priores propositiones elementorum Euclidis. Hic annis fessus cyclos artemque repono. Succedent in hoc munus alii fortasse magis vegeto corpore et vivido ingenio.* Il ne faut pas une heure à un esprit mediocre, pour apprendre par lui même, ou par le secours du plus petit géometre qu'il y ait, les definitions, demandes, axiomes, et les huit premières propositions d'Euclide: et voici un auteur qui parle de cette entreprise, comme de quelque chose de fort grand, et de fort difficile. Il a peur que les forces lui manquent; *Si vires et valetudo suffecerint.* Il laisse à ses successeurs à pousser ces choses: *cætera post me venientibus relinquere.* Il remercie Dieu de ce que, par une grace particulière, il a executé ce qu'il avoit promis: *exsolvi per Dei gratiam promissum, liberavi fidem meam, explicavi pro modulo meo.* Quoi? la quadrature du cercle? la duplication du cube? Ce grand homme a expliqué *pro modulò suo*, les definitions, les demandes, les axiomes, et les huit premières propositions du premier livre des *Elemens* d'Euclide. Peut-être qu'entre ceux qui lui succederont, il s'en trouvera qui auront plus de santé, et plus de force que lui pour continuer ce bel ouvrage: *Succedent in hoc munus alii* FORTASSE *magis vegeto corpore, et vivido ingenio.* Mais pour lui il est tems qu'il se repose; *hic annis fessus cyclos artemque repono.*"

After reading the above passage, it is impossible to avoid reflecting, with satisfaction, on the effect which the progress of philosophy has since had, in removing those obstacles to the acquisition of useful knowledge, which were created by the pedantic taste prevalent two centuries ago. What a contrast to a quarto commentary on the definitions, postulates, axioms, and first eight propositions of Euclid's First Book, is presented by Condorcet's estimate of the time now sufficient to conduct a student to the highest branches of mathematics! "Dans le siècle dernier, il suffisoit de quelques années d'étude pour savoir tout ce qu'Archimede et Hipparque avoient pu connoître; et aujourd'hui deux années de l'enseignement d'un professeur vont au dela de ce que savoient Leibnitz ou Newton." *(Sur l'Instruction Publique.)* In this particular science, I am aware that much is to be ascribed to the subsequent invention of new and more general *methods;* but, I apprehend, not a little also to the improvements gradually suggested by experience, in what Bacon calls the *traditive* part of logic.

[1] Sir Henry Savile. The work here referred to is a 4to volume, entitled, *Prelectiones xiii. in Principium Elementorum Euclidis*, Oxoniæ habitæ, Anno 1620.

1. I have already taken notice of Malebranche's comments on the Cartesian doctrine concerning the *sensible*, or, as they are now more commonly called, *the secondary qualities* of matter. The same fulness and happiness of illustration are everywhere else to be found in his elucidations of his master's system; to the popularity of which he certainly contributed greatly by the liveliness of his fancy, and the charms of his composition. Even in *this* part of his writings, he always preserves the air of an original thinker; and, while pursuing the same path with Descartes, seems rather to have accidentally struck into it from his own casual choice, than to have selected it out of any deference for the judgment of another. Perhaps it may be doubted, if it is not on such occasions, that the inventive powers of his genius, by being somewhat restrained and guided in their aim, are most vigorously and most usefully displayed.

In confirmation of this last remark, I shall only mention, by way of examples, his comments on the Cartesian theory of Vision,—more especially on that part of it which relates to our experimental estimates of the distances and magnitudes of objects; and his admirable illustration of the errors to which we are liable from the illusions of sense, of imagination, and of the passions. In his physiological reveries on the union of soul and body, he wanders, like his master, in the dark, from the total want of facts as a foundation for his reasonings; but even here his genius has had no inconsiderable influence on the inquiries of later writers. The fundamental principle of Hartley is most explicitly stated in *The Search after Truth;*[1] as well as a hypothesis concerning the nature of *habits*, which, rash and unwarranted as it must now appear to every novice in science, was not thought unworthy of adoption in *The Essay on Human Understanding.*[2]

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1 "Toutes nos différentes perceptions sont attachées aux différens changemens qui arrivent dans les fibres de la partie principale du cerveau dans laquelle l'ame réside plus particulièrement." (*Rech. de la Vérité*, Liv. ii. chap. v.) These *changes* in the fibres of the brain are commonly called by Malebranche *ebranlemens;*—a word which is frequently rendered by his old English translator (Taylor) *vibrations*. "La seconde chose," says Malebranche, "qui se trouve dans chacune des sensations, est *l'ebranlement* des fibres de nos nerfs, qui se communique jusqu'au cerveau:" thus translated by Taylor: "The second thing that occurs in every sensation is the *vibration* of the fibres of our nerves, which is communicated to the brain." (Liv. i. chap. xii.) Nor was the theory of *association* overlooked by Malebranche. See, in particular, the third chapter of his second book, entitled, *De la liaison mutuelle des idées de l'esprit, et des traces du cerveau; et de la liaison mutuelle des traces avec les traces, et des idées avec les idées.*

2 "Mais afin de suivre nôtre explication, il faut remarquer que les esprits ne trouvent pas toujours les chemins, par oû ils doivent passer, assez ouverts et assez libres; et que cela fait qui nous avons de la difficulté à remuer, par exemple, les doigts avec la vitesse qui est nécessaire pour jouer des instrumens de musique, ou les muscles qui servent à la prononciation, pour prononcer les mots d'une langue étrangere: Mais que peu-a-peu *les esprits animaux par leur cours continuel ouvrent et applanissent ces chemins*, en sorte qu'avec le tems

2. Among the opinions which chiefly characterize the system of Malebranche, the leading one is, that the *causes* which it is the aim of philosophy to investigate are only *occasional causes;* and that the Deity is himself the *efficient* and the *immediate cause* of every effect in the universe.[1] From this single principle, the greater part of his distinguishing doctrines may be easily deduced, as obvious corollaries.

That we are completely ignorant of the manner in which *physical causes* and *effects* are connected, and that all our knowledge concerning them amounts merely to a perception of *constant conjunction*, had been before remarked by Hobbes, and more fully shown by Glanville in his *Scepsis Scientifica*. Malebranche, however, has treated the same argument much more profoundly and ably than any of his predecessors, and has, indeed, anticipated Hume in some of the most ingenious reasonings contained in his Essay on *Necessary Connexion*. From these *data*, it was not unnatural for his pious mind to conclude, that what are commonly called *second causes* have no existence; and that the Divine power, incessantly and universally exerted, is, in truth, the connecting link of all the phenomena of nature. It is obvious, that, in this conclusion, he went farther than his premises warranted; for, although no necessary connections among physical events can be traced by our faculties, it does not therefore follow that such connections are impossible. The only sound inference was, that the laws of nature are to be discovered, *not*, as the ancients supposed, by *a priori* reasonings from causes to effects, but by experience and observation. It is but justice to Malebranche to own, that he was one of the first who placed in a just and strong light this fundamental principle of the inductive logic.

On the other hand, the objections to the theory of *occasional causes*, chiefly insisted on by Malebranche's opponents, were far from satisfactory. By some it was alleged, that it ascribed every event to a miraculous interposition of the Deity; as if this objection were not directly met by the general and constant *laws* everywhere manifested to our senses,—in a departure from which laws, the very essence of a *miracle* consists. Nor was it more to the pur-

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ils n'y trouvent plus de resistance. Car c'est dans cette facilité que les esprits animaux ont de passer dans les membres de nôtre corps, que consistent les habitudes." *Rech. de la Vérité*, Liv. ii. chap. v.

"Habits seem to be but trains of motion in the animal spirits, which, once set a-going, continue in the same steps they have been used to, *which, by often treading, are worn into a smooth path.*" Locke, Book ii. chap. xxxiii. § 6.

[1] "Afin qu'on ne puisse plus douter de la fausseté de cette miserable philosophie, il est necessaire de prouver qu'il n'y a qu'un vrai Dieu, parce qu'il n'y a qu'une vraie cause; que la nature ou la force de chaque chose n'est que la volonté de Dieu: que toutes les causes naturelles ne sont point de véritable causes, mais seulement des causes occasionelles." *De la Vérité*, Livre vi. 2de Partie, chap. iii.

pose to contend, that the beauty and perfection of the universe were degraded by excluding the idea of *mechanism;* the whole of this argument turning, as is manifest, upon an application to Omnipotence of ideas borrowed from the limited sphere of human power.[1] As to the study of natural philosophy, it is plainly not at all affected by the hypothesis in question; as the investigation and generalization of the laws of nature, which are its only proper objects, present exactly the same field to our curiosity, whether we suppose these *laws* to be the immediate effects of the Divine agency, or the effects of *second causes,* placed beyond the reach of our faculties.[2]

Such, however, were the chief reasonings opposed to Malebranche by Leibnitz, in order to prepare the way for the system of *Pre-established Harmony;* a system more nearly allied to that of *occasional causes* than its author seems to have suspected, and encumbered with every solid difficulty connected with the other.

From the theory of *occasional causes,* it is easy to trace the process which led Malebranche to conclude, *that we see all things in God.* The same arguments which convinced him, that the Deity carries into execution every *volition* of the mind, in the movements of the body, could not fail to suggest, as a farther consequence, that every *perception* of the mind is the immediate effect of the divine illumination. As to the *manner* in which this illumination is accomplished, the extraordinary hypothesis adopted by Malebranche was forced upon him, by the opinion then universally held, that the immediate objects of our perceptions are not things external, but their *ideas* or images. The only pos-

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[1] This objection, frivolous as it is, was strongly urged by Mr Boyle (*Inquiry into the Vulgar Idea concerning Nature*), and has been copied from him by Mr Hume, Lord Kames, and many other writers. Mr Hume's words are these: "It argues more wisdom to contrive at first the fabric of the world with such perfect foresight, that, of itself, and by its proper operation, it may serve all the purposes of providence, than if the great Creator were obliged every moment to adjust its parts, and animate by his breath all the wheels of that stupendous machine." (*Essay on the Idea of necessary Connexion.*) An observation somewhat similar occurs in the Treatise *De Mundo,* commonly ascribed to Aristotle.

[2] In speaking of the theory of *occasional causes,* Mr Hume has committed a historical mistake, which it may be proper to rectify. "Malebranche," he observes, "and other Cartesians, made the doctrine of the universal and sole efficacy of the Deity, the foundation of all their philosophy. *It had, however, no authority in England.* Locke, Clarke, and Cudworth, never so much as take notice of it, but suppose all along that matter has a real, though subordinate and derived power." *Hume's Essays,* Vol. II. p. 475. Edit. of 1784.

Mr Hume was probably led to connect, in this last sentence, the name of Clarke with those of Locke and Cudworth, by taking for granted that his metaphysical opinions agreed exactly with those commonly ascribed to Sir Isaac Newton. In fact, on the point now in question, his creed was the same with that of Malebranche. The following sentence is very nearly a translation of a passage already quoted from the latter. "The course of nature, truly and properly speaking, is nothing but the will of God producing certain effects in a continued, regular, constant, and uniform manner." *Clarke's Works,* Vol. II. p. 698. Fol. Ed.

sible expedient for reconciling these two articles of his creed, was to transfer the seat of our *ideas* from our own minds to that of the Creator.[1]

In this theory of Malebranche, there is undoubtedly, as Bayle has remarked,[2] an approach to some speculations of the latter Platonists; but there is a much closer coincidence between it and the system of those Hindoo philosophers, who (according to Sir William Jones) "believed that the whole creation was rather an *energy* than a *work*; by which the infinite Mind, who is present at all times, and in all places, exhibits to his creatures a set of perceptions, like a wonderful picture, or piece of music, always varied, yet always uniform."[3]

In some of Malebranche's reasonings upon this subject, he has struck into the same train of thought which was afterwards pursued by Berkeley (an author to whom he bore a very strong resemblance in some of the most characteristical features of his genius); and, had he not been restrained by religious scruples, he would, in all probability, have asserted, not less confidently than his successor, that the existence of matter was demonstrably inconsistent with the principles then universally admitted by philosophers. But this conclusion Malebranche rejects, as not reconcilable with the words of Scripture, that "in the beginning God created the heavens and the earth." "La foi m'apprend que Dieu a crée le ciel et la terre. Elle m'apprend que l'Ecriture est un livre divin. Et ce livre ou son apparence me dit nettement et positivement, qu'il y a mille et mille creatures. Donc voilà toutes mes apparences changées en realités. Il y a des corps; cela est démontré en toute rigueur la foy supposée."[4]

In reflecting on the repeated reproduction of these, and other ancient paradoxes, by modern authors, whom it would be highly unjust to accuse of plagiarism;—still more, in reflecting on the affinity of some of our most refined theories to the popular belief in a remote quarter of the globe, one is almost tempted to suppose, that human invention is li-

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[1] We are indebted to La Harpe for the preservation of an epigrammatic line (*un vers fort plaisant*, as he justly calls it) on this celebrated hypothesis: "*Lui, qui voit tout en Dieu, n'y voit-il pas qu'il est fou?*—C'etoit au moins," La Harpe adds, "un fou qui avoit beaucoup d'esprit."

[2] See his Dictionary, article *Amelius*.

[3] Introduction to a Translation of some Hindoo verses.

[4] *Entretiens sur la Metaphysique*, p. 207.

The celebrated *doubt* of Descartes concerning all truths but the existence of his own *mind* (it cannot be too often repeated), was the real source, not only of the inconsistency of Malebranche on this head, but of the chief metaphysical *puzzles* afterwards started by Berkeley and Hume. The illogical transition by which he attempted to pass from this first principle to other truths, was early remarked by some of his own followers, who were accordingly led to conclude, that no man can have full assurance of anything but of his own individual existence. If the fundamental doubt of Descartes be admitted as reasonable, the conclusion of these philosophers (who were distinguished by the name of *Egoists*), is unavoidable.

mited, like a barrel-organ, to a specific number of tunes. But is it not a fairer inference, that the province of pure Imagination, unbounded as it may at first appear, is narrow, when compared with the regions opened by truth and nature to our powers of observation and reasoning?[1] Prior to the time of Bacon, the physical systems of the learned performed their periodical revolutions in orbits as small as the metaphysical hypotheses of their successors; and yet, who would now set any bounds to our curiosity in the study of the material universe? Is it reasonable to think, that the phenomena of the intellectual world are less various, or less marked with the signatures of Divine wisdom?

It forms an interesting circumstance in the history of the two memorable persons who have suggested these remarks, that they had *once*, and only *once*, the pleasure of a short interview. "The conversation," we are told, "turned on the non-existence of matter. Malebranche, who had an inflammation in his lungs, and whom Berkeley found preparing a medicine in his cell, and cooking it in a small pipkin, exerted his voice so violently in the heat of their dispute, that he increased his disorder, which carried him off a few days after."[2] It is impossible not to regret, that of this interview there is no other record;—or rather, that Berkeley had not made it the ground-work of one of his own dialogues. Fine as his imagination was, it could scarcely have added to the picturesque effect of the real scene.[3]

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[1] The limited number of fables, of humorous tales, and even of jests, which, it should seem, are in circulation over the face of the globe, might perhaps be alleged as an additional confirmation of this idea.

[2] *Biog. Brit.* Vol. II. p. 251.

[3] This interview happened in 1715, when Berkeley was in the thirty-first, and Malebranche in the seventy-seventh year of his age. What a change in the state of the philosophical world (whether for the better or worse is a different question) has taken place in the course of the intervening century!

Dr Warburton, who, even when he thinks the most unsoundly, always possesses the rare merit of thinking for himself, is one of the very few English authors who have spoken of Malebranche with the respect due to his extraordinary talents. "All you say of Malebranche," he observes in a letter to Dr Hurd, "is strictly true; he is an admirable writer. There is something very different in the fortune of Malebranche and Locke. When Malebranche first appeared, it was with a general applause and admiration; when Locke first published his *Essay*, he had hardly a single approver. Now Locke is universal, and Malebranche sunk into obscurity. All this may be easily accounted for. The intrinsic merit of either was out of the question. But Malebranche supported his first appearance on a philosophy in the highest vogue; that philosophy has been overturned by the Newtonian, and Malebranche has fallen with his master. It was to no purpose to tell the world, that Malebranche could stand without him. The public never examines so narrowly. Not but that there was another cause sufficient to do the business; and that is, his debasing his noble work with his system of seeing all things in God. When this happens to a great author, one half of his readers out of folly, the other out of malice, dwell only on the unsound part, and forget the other, or use all their arts to have it forgotten.

"But the sage Locke supported himself by no system on the one hand; nor, on the other, did he dishonour himself by any whimsies. The consequence of which was, that, neither following the fashion, nor strik-

Anthony Arnauld, whom I have already mentioned as one of the theological antagonists of Malebranche, is also entitled to a distinguished rank among the French philosophers of this period. In his book *on true and false ideas,* written in opposition to Malebranche's scheme of our seeing all things in God, he is acknowledged by Dr Reid to have struck the first mortal blow at the *ideal theory*; and to have approximated very nearly to his own refutation of this ancient and inveterate prejudice.[1] A step so important would, of itself, be sufficient to establish his claim to a place in literary history; but what chiefly induces me again to bring forward his name, is the reputation he has so justly acquired by his treatise, entitled *The Art of Thinking*;[2] a treatise written by Arnauld, in conjunction with his friend Nicole, and of which (considering the time when it appeared) it is hardly possible to estimate the merits too highly. No publication certainly, prior to Locke's *Essay*, can be named, containing so much good sense, and so little nonsense on the science of Logic; and very few have *since* appeared on the same subject, which can be justly preferred to it, in point of practical utility. If the author had lived in the present age, or had been less fettered by a prudent regard to existing prejudices, the technical part would probably have been reduced within a still narrower compass; but even there, he has contrived to substitute for the puerile and contemptible examples of common logicians, several interesting illustrations from the physical discoveries of his immediate predecessors; and has indulged himself in some short excursions, which excite a lively regret that he had not, more frequently and freely, given scope to his original reflections. Among these excursions, the most valuable, in my opinion, is the twen-

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ing the imagination, he, at first, had neither followers nor admirers; but being everywhere clear, and everywhere solid, he at length worked his way, and afterwards was subject to no reverses. He was not affected by the new fashions in philosophy, who leaned upon none of the old; nor did he afford ground for the after-attacks of envy and folly by any fanciful hypotheses, which, when grown stale, are the most nauseous of all things."

The foregoing reflections on the opposite fates of these two philosophers, do honour on the whole to Warburton's penetration; but the unqualified panegyric on Locke will be now very generally allowed to furnish an additional example of "that national spirit, which," according to Hume, "forms the great happiness of the English, and leads them to bestow on all their eminent writers such praises and acclamations, as may often appear partial and excessive."

[1] The following very concise and accurate summary of Arnauld's doctrine concerning *ideas*, is given by Brucker. "Antonius Arnaldus, ut argumenta Malebranchii eo fortius everteret, peculiarem sententiam defendit, asseruitque, ideas earumque perceptiones esse unum idemque, et non nisi relationibus differre. Ideam scilicet esse, quatenus ad objectum refertur quod mens considerat; perceptionem vero, quatenus ad ipsam mentem quæ percipit; duplicem tamen illam relationem ad unam pertinere mentis modificationem." *Hist. Phil. de Ideis*, pp. 247, 248.

[2] More commonly known by the name of the *Port-Royal Logic.*

tieth chapter of the third part, which deserves the attention of every logical student, as an important and instructive supplement to the enumeration of sophisms given by Aristotle.[1]

The soundness of judgment, so eminently displayed in the *Art of Thinking*, forms a curious contrast to that passion for theological controversy, and that zeal for what he conceived to be the purity of the Faith, which seem to have been the ruling passions of the author's mind. He lived to the age of eighty-three, continuing to write against Malebranche's opinions concerning *Nature and Grace*, to his last hour. "He died," says his biographer, "in an obscure retreat at Brussels, in 1692, without fortune, and even without the comfort of a servant; *he*, whose nephew had been a Minister of State, and who might himself have been a Cardinal. The pleasure of being able to *publish* his sentiments, was to him a sufficient recompense." Nicole, his friend and companion in arms, worn out at length with these incessant disputes, expressed a wish to retire from the field, and to enjoy repose. "*Repose!*" replied Arnauld; "won't you have the whole of eternity to repose in?"

An anecdote which is told of his infancy, when considered in connection with his subsequent life, affords a good illustration of the force of impressions received in the first dawn of reason. He was amusing himself one day with some childish sport, in the library of the Cardinal du Perron, when he requested of the Cardinal to give him a pen:—And for what purpose, said the Cardinal?—To write books, like you, against the Huguenots. The Cardinal, it is added, who was then old and infirm, could not conceal his

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[1] According to Crousaz, *The Art of Thinking* contributed more than either the *Organon* of Bacon, or the *Method* of Descartes, to improve the established modes of academical education on the Continent. (See the Preface to his *Logic*, printed at Geneva 1724.) Leibnitz himself has mentioned it in the most flattering terms; coupling the name of the author with that of Pascal, a still more illustrious ornament of the *Port-Royal* Society:—"Ingeniosissimus Pascalius in præclara dissertatione de ingenio Geometrico, cujus fragmentum extat in egregio libro celeberrimi viri Antonii Arnaldi de Arte bene Cogitandi," &c.; but lest this encomium from so high an authority should excite a curiosity somewhat out of proportion to the real value of the two works here mentioned, I think it right to add, that the praises bestowed by Leibnitz, whether on living or dead authors, are not always to be strictly and literally interpreted. "No one," says Hume, "is so liable to an excess of admiration as a truly great genius." Wherever Leibnitz has occasion to refer to any work of solid merit, this remark applies to him with peculiar force; partly, it is probable, from his quick and sympathetic perception of congenial excellence, and partly from a generous anxiety to point it out to the notice of the world. It affords, on the other hand, a remarkable illustration of the force of prejudice, that Buffier, a learned and most able Jesuit, should have been so far influenced by the hatred of his order to the Jansenists, as to distinguish the *Port-Royal Logic* with the cold approbation of being "a judicious *compilation* from former works on the same subject;—particularly from a treatise by a Spanish Jesuit, *Fonséca*." *Cours De Sciences*, p. 873. Paris 1732.

joy at the prospect of so hopeful a successor; and, as he was putting the pen into his hand, said, "I give it to *you*, as the dying shepherd Damœtas bequeathed his pipe to the little Corydon."

The name of Pascal (*that prodigy of parts*, as Locke calls him) is more familiar to modern ears, than that of any of the other learned and polished anchorites, who have rendered the sanctuary of *Port-Royal* so illustrious; but his writings furnish few materials for philosophical history. Abstracting from his great merits in mathematics and in physics, his reputation rests chiefly on the *Provincial Letters;* a work from which Voltaire, notwithstanding his strong prejudices against the author, dates the *fixation* of the French language; and of which the same excellent judge has said, that "Molière's best comedies do not excel them in wit, nor the compositions of Bossuet in sublimity." The enthusiastic admiration of Gibbon for this book, which he was accustomed from his youth to read once a year, is well known; and is sufficient to account for the rapture with which it never fails to be spoken of by *the erudite vulgar*[1] in this country. I cannot help, however, suspecting, that it is now more praised than read in Great Britain; so completely have those disputes, to which it owed its first celebrity, lost their interest. Many passages in it, indeed, will always be perused with delight; but it may be questioned, if Gibbon himself would have read it so often from beginning to end, had it not been for the strong hold which ecclesiastical controversies, and the Roman Catholic faith, had early taken of his mind.

In one respect, the *Provincial Letters* are well entitled to the attention of philosophers; inasmuch as they present so faithful and lively a picture of the influence of false religious views in perverting the moral sentiments of mankind. The overwhelming ridicule lavished by Pascal on the whole system of jesuitical casuistry, and the happy effects of his pleasantry in preparing, from a distance, the fall of that formidable order, might be quoted as proofs, that there are at least *some* truths, in whose defence this weapon may be safely employed;—perhaps with *more* advantage than the commanding voice of Reason herself. The mischievous absurdities which it was his aim to correct, scarcely admitted of the gravity of logical discussion; requiring only the extirpation or the prevention of those early prejudices which choke the growth of common sense and of conscience: And for this purpose, what so likely to succeed with the open and generous minds of youth, as Ridicule, managed with decency and taste; more especially when seconded, as in the *Pro-*

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[1] *Eruditum Vulgus.* Plin. *Nat. Hist.* Lib. ii.

*vincial Letters*, by acuteness of argument, and by the powerful eloquence of the heart? In this point of view, few practical moralists can boast of having rendered a more important service than Pascal to the general interests of humanity. Were it not, indeed, for his exquisite satire, we should already be tempted to doubt, if, at so recent a date, it were possible for such extravagancies to have maintained a dangerous ascendant over the human understanding.

The unconnected fragment of Pascal, entitled *Thoughts on Religion*, contains various reflections which are equally just and ingenious; some which are truly sublime; and not a few which are false and puerile: the whole, however, deeply tinctured with that ascetic and morbid melancholy, which seems to have at last produced a partial eclipse of his faculties. Voltaire has animadverted on this fragment with much levity and petulance; mingling, at the same time, with many very exceptionable strictures, several of which it is impossible to dispute the justness. The following reflection is worthy of Addison; and bears a strong resemblance in its spirit to the amiable lessons inculcated in his papers on Cheerfulness:[1] "To consider the world as a dungeon, and the whole human race as so many criminals doomed to execution, is the idea of an enthusiast; to suppose the world to be a seat of delight, where we are to expect nothing but pleasure, is the dream of a Sybarite; but to conclude that the Earth, Man, and the lower Animals, are, all of them, subservient to the purposes of an unerring Providence, is, in my opinion, the system of a wise and good man."

From the sad history of this great and excellent person (on whose deep superstitious gloom it is the more painful to dwell, that, by an unaccountable, though not singular coincidence, it was occasionally brightened by the inoffensive play of a lively and sportive fancy), the eye turns with pleasure to repose on the *mitis sapientia*, and the Elysian imagination of Fenelon. The interval between the deaths of these two writers is indeed considerable; but that between their births does not amount to thirty years; and, in point of education, both enjoyed nearly the same advantages.

The reputation of Fenelon as a philosopher would probably have been higher and more universal than it is, if he had not added to the depth, comprehension, and soundness of his judgment, so rich a variety of those more pleasing and attractive qualities, which are commonly regarded rather as the flowers than the fruits of study. The same remark may be extended to the Fenelon of England, whose ingenious and original essays on the *Pleasures*

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[1] *Spectator*, No. 381 and 387.

*of Imagination* would have been much more valued by modern metaphysicians, had they been less beautifully and happily written. The characteristical excellence, however, of the Archbishop of Cambray, is that *moral wisdom* which (as Shaftesbury has well observed) "comes more from the heart than from the head;" and which seems to depend less on the reach of our reasoning powers, than on the absence of those narrow and malignant passions, which, on all questions of ethics and politics (perhaps I might add of religion also), are the chief source of our speculative errors.

The *Adventures of Telemachus*, when considered as a production of the seventeenth century, and still more as the work of a Roman Catholic Bishop, is a sort of prodigy; and it may, to this day, be confidently recommended, as the best manual extant, for impressing on the minds of youth the leading truths, both of practical morals and of political economy. Nor ought it to be concluded, because these truths appear to lie so near the surface, and command so immediately the cordial assent of the understanding, that they are therefore obvious or tritical; for the case is the same with *all* the truths most essential to human happiness. The importance of agriculture and of religious toleration to the prosperity of states; the criminal impolicy of thwarting the kind arrangements of Providence, by restraints upon commerce; and the duty of legislators to study the laws of the moral world as the ground-work and standard of their own, appear, to minds unsophisticated by inveterate prejudices, as approaching nearly to the class of axioms;—yet, how much ingenious and refined discussion has been employed, even in our own times, to combat the prejudices which everywhere continue to struggle against them; and how remote does the period yet seem, when there is any probability that these prejudices shall be completely abandoned!

"But how," said Telemachus to Narbal, "can such a commerce as this of Tyre be established at Ithaca?" "By the same means," said Narbal, "that have established it here. Receive all strangers with readiness and hospitality; let them find convenience and liberty in your ports; and be careful never to disgust them by avarice or pride: above all, never restrain the freedom of commerce, by rendering it subservient to your own immediate gain. The pecuniary advantages of commerce should be left wholly to those by whose labour it subsists; lest this labour, for want of a sufficient motive, should cease. There are more than equivalent advantages of another kind, which must necessarily result to the Prince from the wealth which a free commerce will bring into his state; and commerce is a kind of spring, which to divert from its natural channel is to lose."[1] Had the same question

[1] Hawkesworth's Translation.

been put to Smith or to Franklin in the present age, what sounder advice could they have offered?

In one of Fenelon's *Dialogues of the Dead*, the following remarkable words are put into the mouth of Socrates: "It is necessary that a people should have written laws, always the same, and consecrated by the whole nation; that these laws should be paramount to every-thing else; that those who govern should derive their authority from *them* alone; possessing an unbounded power to do all the good which the laws prescribe, and restrained from every act of injustice which the laws prohibit."

But it is chiefly in a work which did not appear till many years after his death, that we have an opportunity of tracing the enlargement of Fenelon's political views, and the extent of his Christian charity. It is entitled *Direction pour la Conscience d'un Roi;* and abounds with as liberal and enlightened maxims of government as, under the freest constitutions, have ever been offered by a subject to a sovereign. Where the variety of excellence renders selection so difficult, I must not venture upon any extracts; nor, indeed, would I willingly injure the effect of the whole by quoting detached passages. A few sentences on *liberty of conscience* (which I will not presume to translate) may suffice to convey an idea of the general spirit with which it is animated. "Sur toute chose, ne forcez jamais vos sujets à changer de religion. Nulle puissance humaine ne peut forcer le retranchement impénétrable de la liberté du cœur. La force ne peut jamais persuader les hommes; elle ne fait que des hypocrites. Quand les rois se mêlent de religion, au lieu de la protéger, ils la mettent en servitude. Accordez à tous la tolerance civile, non en approuvant tout comme indifférent, mais en souffrant avec patience tout ce que Dieu souffre, et en tâchant de ramener les hommes par une douce persuasion."

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And so much for the French philosophy of the seventeenth century. The extracts last quoted forewarn us, that we are fast approaching to a new era in the history of the Human Mind. *The glow-worm 'gins to pale his ineffectual fire;* and we *scent the morning air* of the coming day. This era I propose to date from the publications of Locke and of Leibnitz; but the remarks which I have to offer on their writings, and on those of their most distinguished successors, I reserve for the Second Part of this Discourse; confining myself, at present, to a very short retrospect of the state of philosophy, during the preceding period, in some other countries of Europe.[1]

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[1] I have classed *Télémaque* and the *Direction pour la Conscience d'un Roi* with the philosophy of the seven-

## Section III.

### *Progress of Philosophy during the Seventeenth Century, in some parts of Europe, not included in the preceding Review.*

During the first half of the seventeenth century, the philosophical spirit which had arisen with such happy auspices in England and in France, has left behind it few or no traces of its existence in the rest of Europe. On all questions connected with *the science of mind* (a phrase which I here use in its largest acceptation), authority continued to be everywhere mistaken for argument; nor can a single work be named, bearing, in its character, the most distant resemblance to the *Organon* of Bacon; to the *Meditations* of Descartes; or to the bold theories of that sublime genius who, soon after, was to shed so dazzling a lustre on the north of Germany. Kepler and Galileo still lived; the former languishing in poverty at Prague; the latter oppressed with blindness, and with ecclesiastical persecution at Florence; but their pursuits were of a nature altogether foreign to our present subject.

One celebrated work alone, the treatise of Grotius *De Jure Belli et Pacis* (first printed in 1625), arrests our attention among the crowd of useless and forgotten volumes, which were then issuing from the presses of Holland, Germany, and Italy. The influence of this treatise, in giving a new direction to the studies of the learned, was so remarkable, and continued so long to operate with undiminished effect, that it is necessary to allot to the author, and to his successors, a space considerably larger than may, at first sight, seem due to their merits. Notwithstanding the just neglect into which they have lately fallen in our Universities, it will be found, on a close examination, that they form an important link in the history of modern literature. It was from their school that most of our best writers on Ethics have proceeded, and many of our most original inquirers into the Human Mind; and it is to the same school (as I shall endeavour to shew in the Second Part of this Discourse), that we are chiefly indebted for the modern science of Political Economy.[1]

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teenth century, although the publication of the former was not permitted till after the death of Louis XIV., nor that of the latter till 1748. The tardy appearance of both only shows how far the author had shot a-head of the orthodox religion and politics of his times.

[1] From a letter of Grotius, quoted by Gassendi, we learn, that the treatise *De Jure Belli et Pacis* was undertaken at the request of his learned friend Peireskius. "Non otior, sed in illo de jure gentium opere

For the information of those who have not read the treatise *De Jure Belli et Pacis*, it may be proper to observe, that, under this title, Grotius has aimed at a complete system of Natural Law. Condillac says, that he chose the title, in order to excite a more general curiosity; adding (and, I believe, very justly), that many of the most prominent defects of his work may be fairly ascribed to a compliance with the taste of his age. "The author," says Condillac, "was able to think for himself; but he constantly labours to support his conclusions by the authority of others; producing, on many occasions, in support of the most obvious and indisputable propositions, a long string of quotations from the Mosaic law; from the Gospels; from the Fathers of the Church; from the Casuists; and not unfrequently, in the very same paragraph, from Ovid and Aristophanes." In consequence of this cloud of witnesses, always at hand to attest the truth of his axioms, not only is the attention perpetually interrupted and distracted; but the author's reasonings, even when perfectly solid and satisfactory, fail in making a due impression on the reader's mind; while the very little that there probably was of systematical arrangement in the general plan of the book, is totally kept out of view.

In spite of these defects, or rather, perhaps, in consequence of some of them, the impression produced by the treatise in question, on its first publication, was singularly great. The stores of erudition displayed in it, recommended it to the classical scholar; while the happy application of the author's reading to the affairs of human life, drew the attention of such men as Gustavus Adolphus; of his Prime-Minister, the Chancellor Oxenstiern; and of the Elector Palatine, Charles Lewis. The last of these was so struck with it, that he founded at Heidelberg a Professorship for the express purpose of teaching the Law of Nature and Nations;—an office which he bestowed on Puffendorff; the most noted, and, on the whole, the most eminent of those who have aspired to tread in the footsteps of Grotius.

The fundamental principles of Puffendorff possess little merit in point of originality, being a sort of medley of the doctrines of Grotius, with some opinions of Hobbes; but his book is entitled to the praise of comparative conciseness, order, and perspicuity; and accordingly came very generally to supplant the treatise of Grotius, as a manual or institute for students, notwithstanding its immense inferiority in genius, in learning, and in classical composition.

The authors who, in different parts of the Continent, have since employed themselves in commenting on Grotius and Puffendorff; or in abridging their systems; or

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pergo, quod si tale futurum est, ut lectores demereri possit, habebit quod tibi debeat posteritas, qui me ad hunc laborem et auxilio et hortatu tuo excitasti." *Gassendi Opera*, Tom. V. p. 294.

in altering their arrangements, are innumerable; but notwithstanding all their industry and learning, it would be very difficult to name any class of writers, whose labours have been of less utility to the world. The same ideas are constantly recurring in an eternal circle; the opinions of Grotius and of Puffendorff, where they are at all equivocal, are anxiously investigated, and sometimes involved in additional obscurity; while, in the meantime, the science of Natural Jurisprudence never advances one single step; but, notwithstanding its recent birth, seems already sunk into a state of dotage.[1]

In perusing the systems now referred to, it is impossible not to feel a very painful dissatisfaction, from the difficulty of ascertaining the precise object aimed at by the authors. So vague and indeterminate is the general scope of their researches, that not only are different views of the subject taken by different writers, but even by the same writer in different parts of his work;—a circumstance which, of itself, sufficiently accounts for the slender additions they have made to the stock of useful knowledge; and which is the real source of that chaos of heterogeneous discussions, through which the reader is perpetually forced to fight his way. A distinct conception of these different views will be found to throw more light than might at first be expected on the subsequent history of Moral and of Political science; and I shall therefore endeavour, as accurately as I can, to disentangle and separate them from each other, at the risk perhaps of incurring, from some readers, the charge of prolixity. The most important of them may, I apprehend, be referred to one or other of the following heads:

1. Among the different ideas which have been formed of Natural Jurisprudence, one of the most common (particularly in the earlier systems) supposes its object to be—To lay down those rules of justice which *would* be binding on men living in a social state, without any positive institutions; or (as it is frequently called by writers on this subject), living together in a *state of nature*. This idea of the province of Jurisprudence seems to have been uppermost in the mind of Grotius, in various parts of his treatise.

To this speculation about the state of nature, Grotius was manifestly led by his laudable anxiety to counteract the attempts then recently made to undermine the foundations of morality. That moral distinctions are created entirely by the arbitrary and revealed will

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[1] I have borrowed, in this last paragraph, some expressions from Lampredi. "Grotii et Puffendorfii interpretes, viri quidem diligentissimi, sed qui vix fructum aliquem tot commentariis, adnotationibus, compendiis, tabulis, ceterisque ejusmodi aridissimis laboribus attulerunt: perpetuo circulo eadem res circumagitur, quid uterque senserit quæritur, interdum etiam utriusque sententiæ obscurantur; disciplina nostra tamen ne latum quidem unguem progreditur, et dum aliorum sententiæ disquiruntur et explanantur, Rerum Natura quasi senio confecta squalescit, neglectaque jacet et inobservata omnino." (*Juris Publici Theoremata*, p. 34.)

of God, had, before his time, been zealously maintained by some theologians even of the reformed church; while, among the political theorists of the same period, it was not unusual to refer these distinctions (as was afterwards done by Hobbes) to the positive institutions of the civil magistrate. In opposition to both, it was contended by Grotius, that there is a natural law coëval with the human constitution, from which positive institutions derive all their force; a truth which, how obvious and tritical soever it may now appear, was so opposite in its spirit to the illiberal systems taught in the monkish establishments, that he thought it necessary to exhaust in its support all his stores of ancient learning. The older writers on Jurisprudence must, I think, be allowed to have had great merit in dwelling so much on this fundamental principle; a principle which renders "*Man a Law to Himself;*" and which, if it be once admitted, reduces the metaphysical question concerning the nature of the moral faculty to an object merely of speculative curiosity.[1] To this faculty the ancients frequently give the name of *reason;* as in that noted passage of Cicero, where he observes, that "right reason is itself *a law;* congenial to the feelings of nature; diffused among all men; uniform; eternal; calling us imperiously to our duty, and peremptorily prohibiting every violation of it. Nor does it speak," continues the same author, "one language at Rome and another at Athens, varying from place to place, or time to time; but it addresses itself to all nations, and to all ages; deriving its authority from the common sovereign of the universe, and carrying home its sanctions to every breast, by the inevitable punishment which it inflicts on transgressors."[2]

The habit of considering morality under the similitude of *a law*, (*a law* engraved on the human heart,) led not unnaturally to an application to ethical subjects of the technical language and arrangements of the Roman jurisprudence; and this innovation was at once facilitated and encouraged, by certain peculiarities in the nature of the most important of all the virtues,—that of justice; peculiarities which, although first explained fully by

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[1] "Upon whatever we suppose that our moral faculties are founded, whether upon a certain modification of reason, upon an original instinct, called a moral sense, or upon some other principle of our nature, it cannot be doubted that they were given us for the direction of our conduct in this life. They carry along with them the most evident badges of this authority, which denote that they were set up within us to be the supreme arbiters of all our actions, to superintend all our senses, passions, and appetites, and to judge how far each of them was either to be indulged or restrained. The rules, therefore, which they prescribe, are to be regarded as the commands and *laws of the Deity*, promulgated by those vicegerents which he has set up within us." (Smith's *Theory of Moral Sentiments*, Part iii. chap. v.)—See also Dr Butler's very original and philosophical *Discourses on Human Nature.*

[2] *Frag.* Lib. iii. *de Rep.*

Hume and Smith, were too prominent to escape altogether the notice of preceding moralists.

The circumstances which distinguish justice from the other virtues, are chiefly two. In the first place, its rules may be laid down with a degree of accuracy, whereof moral precepts do not, in any other instance, admit. Secondly, its rules may be enforced, inasmuch as every transgression of them implies a violation of the rights of others. For the illustration of both propositions, I must refer to the eminent authors just mentioned.

As, in the case of justice, there is always a right, on the one hand, corresponding to an obligation on the other, the various rules enjoined by it may be stated in two different forms; either as a system of duties, or as a system of rights. The former view of the subject belongs properly to the moralist—the latter to the lawyer. It is this last view that the writers on Natural Jurisprudence (most of whom were lawyers by profession) have in general chosen to adopt; although, in the same works, both views will be found to be not unfrequently blended together.

To some indistinct conception among the earlier writers on Natural Law, of these peculiarities in the nature of justice, we may probably ascribe the remarkable contrast pointed out by Mr Smith, between the ethical systems of ancient and of modern times. "In none of the ancient moralists," he observes, "do we find any attempt towards a particular enumeration of the rules of justice. On the contrary, Cicero in his Offices, and Aristotle in his Ethics, treat of justice in the same general manner in which they treat of generosity or of charity."[1]

But, although the rules of justice are in every case precise and indispensable; and although their authority is altogether independent of that of the civil magistrate, it would obviously be absurd to spend much time in speculating about the principles of this natural law, as applicable to men, before the establishment of government. The same state of society which diversifies the condition of individuals to so great a degree as to suggest problematical questions with respect to their rights and their duties, necessarily gives birth to certain conventional laws or customs, by which the conduct of the different members of the association is to be guided; and agreeably to which the disputes that may arise among them are to be adjusted. The imaginary state referred to under the title of the *State of Nature*, though it certainly does not exclude the idea of *a moral right of property arising from labour*, yet it excludes all that variety of cases concerning its alienation

[1] *Theory of Moral Sentiments*, Part vii. sect. iv.

and transmission, and the mutual covenants of parties, which the political union alone could create;—an order of things, indeed, which is virtually supposed in almost all the speculations about which the law of nature is commonly employed.

2. It was probably in consequence of the very narrow field of study which Jurisprudence, considered in this light, was found to open, that its province was gradually enlarged, so as to comprehend, not merely the rules of justice, but the rules enjoining all our other moral duties. Nor was it only the *province* of Jurisprudence which was thus enlarged. A corresponding extension was also given, by the help of arbitrary definitions, to its *technical phraseology*, till at length the whole doctrines of practical ethics came to be moulded into an artificial form, originally copied from the Roman code. Although justice is the only branch of virtue in which every moral Obligation implies a corresponding Right, the writers on Natural Law have contrived, by fictions of *imperfect rights*, and of *external rights*, to treat indirectly of all our various duties, by pointing out the rights which are supposed to be their correlates:—in other words, they have contrived to exhibit, in the form of a system of rights, a connected view of the whole duty of man. This idea of Jurisprudence, which identifies its object with that of Moral Philosophy, seems to coincide nearly with that of Puffendorff; and some vague notion of the same sort has manifestly given birth to many of the digressions of Grotius.

Whatever judgment may now be pronounced on the effects of this innovation, it is certain that they were considered, not only at the time, but for many years afterwards, as highly favourable. A very learned and respectable writer, Mr Carmichael of Glasgow, compares them to the improvements made in Natural Philosophy by the followers of Lord Bacon. "No person," he observes, "liberally educated, can be ignorant, that, within the recollection of ourselves and of our fathers, philosophy has advanced to a state of progressive improvement hitherto unexampled; in consequence partly of the rejection of scholastic absurdities, and partly of the accession of new discoveries. Nor does this remark apply solely to Natural Philosophy, in which the improvements accomplished by the united labours of the learned have forced themselves on the notice even of the vulgar, by their palpable influence on the mechanical arts. The other branches of philosophy also have been prosecuted during the last century with no less success; and none of them in a more remarkable degree than the science of Morals.

"This science, so much esteemed, and so assiduously cultivated by the sages of antiquity, lay, for a length of time, in common with all the other useful arts, buried in the rubbish of the dark ages, till (soon after the commencement of the seventeenth century), the

incomparable treatise of *Grotius de Jure Belli et Pacis* restored to more than its ancient splendour that part of it which defines the relative duties of individuals; and which, in consequence of the immense variety of cases comprehended under it, is by far the most extensive of any. Since that period, the most learned and polite scholars of Europe, as if suddenly roused by the alarm of a trumpet, have vied with each other in the prosecution of this study,—so strongly recommended to their attention, not merely by its novelty, but by the importance of its conclusions, and the dignity of its object."[1]

I have selected this passage, in preference to many others that might be quoted to the same purpose from writers of higher name; because, in the sequel of this historical sketch, it appears to me peculiarly interesting to mark the progress of Ethical and Political specula-

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[1] The last sentence is thus expressed in the original. "Ex illo tempore, quasi classico dato, ab eruditissimis passim et politissimis viris excoli certatim cæpit, utilissima hæc nobilissimaque doctrina." (See the edition of Puffendorff, *De officio Hominis et Civis*, by Professor Gerschom Carmichael of Glasgow, 1724); an author whom Dr Hutcheson pronounces to be "by far the best commentator on Puffendorff; and "whose *notes*," he adds, "are of much more value than the *text*." See his short *Introduction to Moral Philosophy*.

Puffendorff's principal work, entitled *De Jure Naturæ et Gentium*, was first printed in 1672, and was afterwards abridged by the author into the small volume referred to in the foregoing paragraph. The idea of Puffendorff's aim, formed by Mr Carmichael, coincides exactly with the account of it given in the text: "Hoc demum tractatu edito, facile intellexerunt æquiores harum rerum arbitri, non aliam esse genuinam *Morum Philosophiam*, quam quæ ex evidentibus principiis, in ipsa rerum natura fundatis, hominis atque civis officia, in singulis vitæ humanæ circumstantiis debita, eruit ac demonstrat; atque adeo Juris Naturalis scientiam, quantumvis diversam ab Ethica quæ in scholis dudum obtinuerat, præ se ferret faciem, non esse, quod ad scopum et rem tractandam, verè aliam disciplinam, sed eandem rectius duntaxat et solidius traditam, ita ut, ad quam prius male collineaverit, tandem reipsâ feriret scopum." See Carmichael's edition of the Treatise *De Officio Hominus et Civis*, p. 7.

To so late a period did this admiration of the Treatise, *De Officio Hominis et Civis*, continue in our Scotch Universities, that the very learned and respectable Sir John Pringle (afterwards President of the Royal Society of London), adopted it as the text-book for his lectures, while he held the Professorship of Moral Philosophy at Edinburgh. Nor does the case seem to have been different in England. "I am going," says Gray, in a letter written while a student at Cambridge, "to attend a lecture on *one* Puffendorff." And, much in the same spirit, Voltaire thus expresses himself with respect to the schools of the Continent: "On est partagé, dans les écoles, entre Grotius et Puffendorff. Croyez moi, lisez les Offices de Ciceron." From the contemptuous tone of these two writers, it should seem that the old systems of Natural Jurisprudence had entirely lost their credit among men of taste and of enlarged views, long before they ceased to form an essential part of academical instruction; thus affording an additional confirmation of Mr Smith's complaint, that "the greater part of universities have not been very forward to adopt improvements after they were made; and that several of those learned societies have chosen to remain, for a long time, the sanctuaries in which exploded systems found shelter and protection, after they had been hunted out of every other corner of the world." Considering his own successful exertions, in his academical capacity, to remedy this evil, it is more than probable that Mr Smith had Grotius and Puffendorff in his view, when he wrote the foregoing sentence.

tion in that seat of learning, which, not many years afterwards, was to give birth to the *Theory of Moral Sentiments*, and to the *Inquiry into the Nature and Causes of the Wealth of Nations*. The powerful effect which the last of these works has produced on the political opinions of the whole civilized world, renders it unnecessary, in a Discourse destined to form part of a Scotish *Encyclopædia*, to offer any apology for attempting to trace, with some minuteness, the train of thought by which an undertaking, so highly honourable to the literary character of our country, seems to have been suggested to the author.

The extravagance of the praise lavished on Grotius and Puffendorff, in the above citation from Carmichael, can be accounted for only by the degraded state into which Ethics had fallen in the hands of those who were led to the study of it, either as a preparation for the casuistical discussions subservient to the practice of auricular confession, or to justify a scheme of morality which recommended the useless austerities of an ascetic retirement, in preference to the manly duties of social life. The practical doctrines inculcated by the writers on Natural Law, were all of them favourable to active virtue; and, how reprehensible soever in point of form, were not only harmless, but highly beneficial in their tendency. They were at the same time so diversified (particularly in the work of Grotius) with beautiful quotations from the Greek and Roman classics, that they could not fail to present a striking contrast to the absurd and illiberal systems which they supplanted; and perhaps to these passages, to which they thus gave a sort of systematical connection, the progress which the science made in the course of the eighteenth century, may, in no inconsiderable degree, be ascribed. Even now, when so very different a taste prevails, the treatise *de Jure Belli et Pacis* possesses many charms to a classical reader; who, although he may not always set a very high value on the author's reasonings, must at least be dazzled and delighted with the splendid profusion of his learning.

The field of Natural Jurisprudence, however, was not long to remain circumscribed within the narrow limits commonly assigned to the province of Ethics. The contrast between natural law and positive institution, which it constantly presents to the mind, gradually and insensibly suggested the idea of comprehending under it every question concerning right and wrong, on which positive law is silent. Hence the origin of two different departments of Jurisprudence, little attended to by some of the first authors who treated of it, but afterwards, from their practical importance, gradually encroaching more and more on those ethical disquisitions by which they were suggested. Of these departments, the one refers to the conduct of individuals in those violent and critical moments when the bonds of political society are torn asunder; the other, to the mutual relations of independent communities. The questions connected with the former article, lie indeed within a compara-

tively narrow compass; but on the latter so much has been written, that what was formerly called Natural Jurisprudence, has been, in later times, not unfrequently distinguished by the title of the *Law of Nature and Nations.* The train of thought by which both subjects came to be connected with the systems now under consideration, consists of a few very simple and obvious steps.

As an individual who is a member of a political body necessarily gives up his will to that of the governors who are entrusted by the people with the supreme power, it is his duty to submit to those inconveniences which, in consequence of the imperfection of all human establishments, may incidentally fall to his own lot. This duty is founded on the Law of Nature, from which, indeed, (as must appear evident on the slightest reflection) conventional law derives all its *moral* force and obligation. The great end, however, of the political union being a sense of general utility, if this end should be manifestly frustrated, either by the injustice of laws, or the tyranny of rulers, individuals must have recourse to the principles of natural law, in order to determine how far it is competent for them to withdraw themselves from their country, or to resist its governors by force. To Jurisprudence, therefore, considered in this light, came with great propriety to be referred all those practical discussions which relate to the limits of allegiance, and the right of resistance.

By a step equally simple, the province of the science was still farther extended. As independent states acknowledge no superior, the obvious inference was, that the disputes arising among them must be determined by an appeal to the Law of Nature; and accordingly, this law, when applied to states, forms a separate part of Jurisprudence, under the title of the Law of Nations. By some writers we are told, that the general principles of the Law of Nature, and of the Law of Nations, are one and the same, and that the distinction between them is merely verbal. To this opinion, which is very confidently stated by Hobbes,[1]

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[1] "Lex Naturalis dividi potest in naturalem hominum quæ sola obtinuit dici Lex Naturæ, et naturalem civitatum, quæ dici potest Lex Gentium, vulgo autem Jus Gentium appellatur. Præcepta utriusque eadem sunt; sed quia civitates semel institutæ induunt proprietates hominum personales, lex quam loquentes de hominum singulorum officio naturalem dicimus, applicata totis civitatibus, nationibus, sive gentibus, vocatur Jus Gentium." *De Cive*, cap. xiv. § 4.

In a late publication, from the title of which some attention to dates might have been expected, we are told, that "Hobbes's book *De Cive* appeared but a little time *before* the treatise of Grotius;" whereas, in point of fact, Hobbes's book did not *appear* till twenty-two years *after* it. A few copies were indeed printed at Paris, and privately circulated by Hobbes, as early as 1642, but the book was not published till 1647. (See "*An Inquiry into the Foundation and History of the Law of Nations in Europe*, &c." by Robert Ward of the Inner-Temple, Esq. London, 1795). This inaccuracy, however, is trifling, when compared with those committed in the same work, in stating the distinguishing doctrines of the two systems.

As a writer on the Law of Nations, Hobbes is now altogether unworthy of notice. I shall therefore only re-

Puffendorff has given his sanction; and, in conformity to it, contents himself with laying down the general principles of natural law, leaving it to the reader to apply it as he may find necessary, to individuals or to societies.

The later writers on Jurisprudence have thought it expedient to separate the law of nations from that part of the science which treats of the duties of individuals; [1] but without being at sufficient pains to form to themselves a definite idea of the object of their studies. Whoever takes the trouble to look into their systems, will immediately perceive, that their leading aim is not (as might have been expected), to ascertain the great principles of morality binding on all nations in their intercourse with each other; or to point out with what limitations the ethical rules recognized among individuals must be understood, when extended to political and unconnected bodies; but to exhibit a digest of those laws and usages, which, partly from considerations of utility, partly from accidental circumstances, and partly from positive conventions, have gradually arisen among those states of Christendom, which, from their mutual connections, may be considered as forming one great republic. It is evident, that such a digest has no more connection with the Law of Nature, properly so called, than it has with the rules of the Roman law, or of any other municipal code. The details contained in it are highly interesting and useful in themselves; but they belong to a science altogether different; a science, in which the ultimate appeal is made, not to ab-

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mark on this part of his philosophy, that its aim is precisely the *reverse* of that of Grotius; the latter labouring, through the whole of his treatise, to extend, as far as possible, among independent states, the same laws of justice and of humanity, which are universally recognized among individuals; while Hobbes, by *inverting* the argument, exerts his ingenuity to shew, that the moral repulsion which commonly exists between independent and neighbouring communities, is an exact picture of that which existed among individuals prior to the origin of government. The inference, indeed, was most illogical, inasmuch as it is the social attraction among individuals which is the source of the mutual repulsion among nations: and as this attraction invariably operates with the greatest force where the individual is the most completely independent of his species, and where the advantages of the political union are the least sensibly felt. If, in any state of human nature, it be in danger of becoming quite evanescent, it is in large and civilized empires, where man becomes indispensably necessary to man; depending for the gratification of his artificial wants on the co-operation of thousands of his fellow-citizens.

Let me add, that the theory, so fashionable at present, which resolves the whole of morality into the principle of *utility*, is more nearly akin to Hobbism, than some of its partisans are aware of.

[1] The credit of this improvement is ascribed by Vattel (one of the most esteemed writers on the subject), to the celebrated German philosopher Wolfius, whose labours in this department of study he estimates very highly. (*Questions de Droit Naturel.* Berne, 1762.) Of this great work I know nothing but the title, which is not calculated to excite much curiosity in the present times: "Christiani Wolfii *jus Naturæ methodo scientifica pertractatum*, in 9 Tomos distributum." (Francof. 1740.) "Non est," says Lampredi, *himself* a professor of public law, "qui non deterreatur tanta librorum farragine, quasi vero Herculeo labore opus esset, ut quis honestatem et justitiam addiscat."

stract maxims of right and wrong, but to precedents, to established customs, and to the authority of the learned.

The intimate alliance, however, thus established between the Law of Nature and the conventional Law of Nations, has been on the whole attended with fortunate effects. In consequence of the discussions concerning questions of justice and of expediency which came to be blended with the details of public law, more enlarged and philosophical views have gradually presented themselves to the minds of speculative statesmen; and, in the last result, have led, by easy steps, to those liberal doctrines concerning commercial policy, and the other mutual relations of separate and independent states, which, if they should ever become the creed of the rulers of mankind, promise so large an accession to human happiness.

3. Another idea of Natural Jurisprudence, essentially distinct from those hitherto mentioned, remains to be considered. According to this, its object is to ascertain the general principles of justice which *ought to be* recognized in every municipal code; and to which it *ought to be* the aim of every legislator to accommodate his institutions. It is to this idea of Jurisprudence that Mr Smith has given his sanction in the conclusion of his Theory of Moral Sentiments; and this he seems to have conceived to have been likewise the idea of Grotius, in the treatise *de Jure Belli et Pacis*.

"It might have been expected," says Mr Smith, "that the reasonings of lawyers upon the different imperfections and improvements of the laws of different countries, should have given occasion to an inquiry into what were the natural rules of justice, independent of all positive institution. It might have been expected, that these reasonings should have led them to aim at establishing a system of what might properly be called Natural Jurisprudence, or *a theory of the principles which ought to run through, and to be the foundation of the laws of all nations.* But, though the reasonings of lawyers did produce something of this kind, and though no man has treated systematically of the laws of any particular country, without intermixing in his work many observations of this sort, it was very late in the world before any such general system was thought of, or before the philosophy of laws was treated of by itself, and without regard to the particular institutions of any nation. Grotius seems to have been the first who attempted to give the world anything like a system of those principles which ought to run through, and be the foundation of the laws of all nations; and his Treatise of the Laws of Peace and War, with all its imperfections, is perhaps, at this day, the most complete work that has yet been given on the subject."

Whether this was, or was not, the leading object of Grotius, it is not material to decide; but if this *was* his object, it will not be disputed that he has executed his design in a very desultory manner, and that he often seems to have lost sight of it altogether, in the midst

of those miscellaneous speculations on political, ethical, and historical subjects, which form so large a portion of his Treatise, and which so frequently succeed each other without any apparent connection or common aim. [1]

Nor do the views of Grotius appear always enlarged or just, even when he is pointing at the object described by Mr Smith. The Roman system of Jurisprudence seems to have warped, in no inconsiderable degree, his notions on all questions connected with the theory of legislation, and to have diverted his attention from that philosophical idea of law, so well expressed by Cicero,—" Non à prætoris edicto, neque à duodecim tabulis, sed penitus ex intimâ philosophiâ, hauriendam juris disciplinam." In this idolatry, indeed, of the Roman law, he has not gone so far as some of his commentators, who have affirmed, that it is only a different name for the Law of Nature; but that his partiality for his professional pursuits has often led him to overlook the immense difference between the state of society in ancient and modern Europe, will not, I believe, be now disputed. It must, at the same time, be mentioned to his praise, that no writer appears to have been, *in theory*, more completely aware of the essential distinction between Natural and Municipal laws. In one of the paragraphs of his *Prolegomena*, he mentions it as a part of his general plan, to illustrate the Roman code, and to systematize those parts of it which have their origin in the Law of Nature. " The task," says he, " of moulding it into the form of a system, has been projected by many, but hitherto accomplished by none. Nor indeed was the thing possible, while so little attention was paid to the distinction between natural and positive institutions; for the former being everywhere the same, may be easily traced to a few general principles, while the latter, exhibiting different appearances at different times, and in different places, elude every attempt towards methodical arrangement, no less than the insulated facts which individual objects present to our external senses."

This passage of Grotius has given great offence to two of the most eminent of his commentators, Henry and Samuel de Cocceii, who have laboured much to vindicate the Roman legislators against that indirect censure which the words of Grotius appear to convey. " My chief object," says the latter of those writers, " was, by deducing the Roman law from its source in the nature of things, to reconcile Natural Jurisprudence with the civil code; and, at the same time, to correct the supposition implied in the foregoing passage of Grotius, which is indeed one of the most exceptionable to be found in his work. The re-

[1] " Of what stamp," says a most ingenious and original thinker, " are the works of Grotius, Puffendorff, and Burlemaqui? Are they political or ethical, historical or juridical, expository or censorial?—Sometimes one thing, sometimes another: they seem hardly to have settled the matter with themselves." Bentham's *Introduction to the Principles of Morals and Legislation*, p. 327.

marks on this subject, scattered over the following commentary, the reader will find arranged in due order in my twelfth Preliminary Dissertation, the chief design of which is to systematize the whole Roman law, and to demonstrate its beautiful coincidence with the Law of Nature." In the execution of this design, Cocceii must, I think, be allowed to have contributed a very useful supplement to the jurisprudential labours of Grotius, the Dissertation in question being eminently distinguished by that distinct and luminous method, the want of which renders the study of the treatise *de Jure Belli et Pacis* so peculiarly irksome and unsatisfactory.

The superstitious veneration for the Roman code expressed by such writers as the Cocceii, will appear less wonderful, when we attend to the influence of the same prejudice on the liberal and philosophical mind of Leibnitz; an author, who has not only gone so far as to compare the civil law (considered as a monument of human genius) with the remains of the ancient Greek geometry; but has strongly intimated his dissent from the opinions of those who have represented its principles as being frequently at variance with the Law of Nature. In one very powerful paragraph, he expresses himself thus: "I have often said, that, after the writings of geometricians, there exists nothing which, in point of strength, subtilty, and depth, can be compared to the works of the Roman lawyers. And as it would be scarcely possible, from mere intrinsic evidence, to distinguish a demonstration of Euclid's from one of Archimedes or of Appollonius (the style of all of them appearing no less uniform than if reason herself were speaking through their organs,) so also the Roman lawyers all resemble each other like twin-brothers; insomuch that, from the style alone of any particular opinion or argument, hardly any conjecture could be formed about its author. Nor are the traces of a refined and deeply meditated system of Natural Jurisprudence anywhere to be found more visible, or in greater abundance. And even in those cases where its principles are departed from, either in compliance with the language consecrated by technical forms, or in consequence of new statutes, or of ancient traditions, the conclusions which the assumed hypothesis renders it necessary to incorporate with the eternal dictates of right reason, are deduced with the soundest logic, and with an ingenuity that excites admiration. *Nor are these deviations from the Law of Nature so frequent as is commonly apprehended.*"

In the last sentence of this passage, Leibnitz had probably an eye to the works of Grotius and his followers; which, however narrow and timid in their views they may now appear, were, for a long time, regarded among civilians as savouring somewhat of theoretical innovation, and of political heresy.

To all this may be added, as a defect still more important and radical in the systems of

Natural Jurisprudence considered as models of universal legislation, that their authors reason concerning laws too abstractedly, without specifying the particular circumstances of the society to which they mean that their conclusions should be applied. It is very justly observed by Mr Bentham, that, " if there are any books of universal Jurisprudence, they must be looked for within very narrow limits." He certainly, however, carries this idea too far, when he asserts, that " to be susceptible of an universal application, *all* that a book of the expository kind can have to treat of, is *the import of words* ; and that, to be strictly speaking universal, it must confine itself to terminology ; that is, to an explanation of such words connected with law, as *power, right, obligation, liberty,* to which are words pretty exactly correspondent in all languages." [1] His expressions, too, are somewhat unguarded, when he calls the *Law of Nature* " an obscure phantom, which, in the imaginations of those who go in chace of it, points sometimes to *manners,* sometimes to *laws,* sometimes to what law *is,* sometimes to what it *ought to be.* [2] Nothing, indeed, can be more exact and judicious than this description, when restricted to the *Law of Nature,* as commonly treated of by writers on Jurisprudence ; but if extended to the *Law of Nature,* as originally understood among ethical writers, it is impossible to assent to it, without abandoning all the principles on which the science of morals ultimately rests. With these obvious, but, in my opinion, very essential limitations, I perfectly agree with Mr Bentham, in considering an abstract code of laws as a thing equally unphilosophical in the design, and useless in the execution.

In stating these observations, I would not be understood to dispute the utility of turning the attention of students to a comparative view of the municipal institutions of different nations ; but only to express my doubts whether this can be done with advantage, by referring these institutions to that abstract theory called the *Law of Nature,* as to a common standard. The code of some particular country must be fixed on as a ground-work for our speculations ; and its laws studied, not as consequences of any abstract principles of justice, but in their connection with the circumstances of the people among whom they originated. A comparison of these laws with the corresponding laws of other nations, considered also in their connection with the circumstances whence they arose, would form a branch of study equally interesting and useful ; not merely to those who have in view the profession of law, but to all who receive the advantages of a liberal education. In fixing on such a standard, the preference must undoubtedly be given to the Roman law, if for no other reason than this, that its technical language is more or less incorporated with all our municipal regulations in this part of the world : and the study of this language, as well as of the other technical parts of

[1] *Introduction to the Principles of Morals and Legislation,* p. 323. [2] Ibid. p. 327.

Jurisprudence (so revolting to the taste when considered as the arbitrary jargon of a philosophical theory), would possess sufficient attractions to excite the curiosity, when considered as a necessary passport to a knowledge of that system, which so long determined the rights of the greatest and most celebrated of nations.

"Universal grammar," says Dr Lowth, "cannot be taught abstractedly; it must be done with reference to some language already known, in which the terms are to be explained and the rules exemplified."[1] The same observation may be applied (and for reasons strikingly analogous) to the science of Natural or Universal Jurisprudence.

Of the truth of this last proposition Bacon seems to have been fully aware; and it was manifestly some ideas of the same kind which gave birth to Montesquieu's historical speculations with respect to the origin of laws, and the reference which they may be expected to bear, in different parts of the world, to the physical and moral circumstances of the nations among whom they have sprung up. During this long interval, it would be difficult to name any intermediate writer, by whom the important considerations just stated were duly attended to.

In touching formerly on some of Bacon's ideas concerning the philosophy of law, I quoted a few of the most prominent of those fortunate anticipations, so profusely scattered over his works, which, outstripping the ordinary march of human reason, associate his mind with the luminaries of the eighteenth century, rather than with his own contemporaries. These anticipations, as well as many others of a similar description, hazarded by his bold yet prophetic imagination, have often struck me as resembling the *pierres d'attente* jutting out from the corners of an ancient building, and inviting the fancy to complete what was left unfinished of the architect's design;—or the slight and broken sketches traced on the skirts of an American map, to connect its chains of hills and branches of rivers with some future survey of the contiguous wilderness. Yielding to such impressions, and eager to pursue the rapid flight of his genius, let me abandon for a moment the order of time, while I pass from the *Fontes Juris* to the *Spirit of Laws*. To have a just conception of the comparatively limited views of Grotius, it is necessary to attend to what was planned by his immediate predecessor, and first executed (or rather first *begun* to be executed) by one of his remote successors.

The main object of the *Spirit of Laws* (it is necessary here to premise) is to show, not, as has been frequently supposed, what laws *ought* to be,—but how the diversities in the physical and moral circumstances of the human race have contributed to produce diversities

[1] Preface to his *English Grammar*.

in their political establishments, and in their municipal regulations.[1] On this point, indeed, an appeal may be made to the author himself. "I write not," says he, "to censure anything established in any country whatsoever; every nation will here find the *reasons* on which its maxims are founded." This plan, however, which, when understood with proper limitations, is highly philosophical, and which raises Jurisprudence, from the uninteresting and useless state in which we find it in Grotius and Puffendorff, to be one of the most agreeable and important branches of useful knowledge (although the execution of it occupies by far the greater part of his work), is prosecuted by Montesquieu in so very desultory a manner, that I am inclined to think he rather fell into it insensibly, in consequence of the occasional impulse of accidental curiosity, than from any regular design he had formed to himself when he began to collect materials for that celebrated performance. He seems, indeed, to confess this in the following passage of his preface: "Often have I begun, and as often laid aside, this undertaking. I have followed my observations without any fixed plan, and without thinking either of rules or exceptions. I have found the truth only to lose it again."

But whatever opinion we may form on this point, Montesquieu enjoys an unquestionable claim to the grand idea of connecting Jurisprudence with History and Philosophy, in such a manner as to render them all subservient to their mutual illustration. Some occasional disquisitions of the same kind may, it is true, be traced in earlier writers, particularly in the works of Bodinus; but they are of a nature too trifling to detract from the glory of Montesquieu. When we compare the jurisprudential researches of the latter with the systems previously in possession of the schools, the step which he made appears to have been so vast as almost to justify the somewhat too ostentatious motto prefixed to them by the author; *Prolem sine Matre creatam.* Instead of confining himself, after the example of his predecessors, to an interpretation of one part of the Roman code by another, he studied the SPIRIT of these laws in the political views of their authors, and in the peculiar circumstances of that extraordinary race. He combined the science of law with the history of political society, employing the latter to account for the varying aims of the legislator; and the former, in its turn, to explain the nature of the government, and the manners of the people. Nor did he limit his inquiries to the Roman law, and to Roman history; but, convinced that the general principles of human nature are everywhere the same, he searched for new lights among the subjects of every government, and the inhabitants of every climate; and, while he thus opened inex-

[1] This, though somewhat ambiguously expressed, *must*, I think, have been the idea of D'Alembert in the following sentence: "Dans cet ouvrage, M. de Montesquieu s'occupe moins des loix qu'on a faites, que de celles qu'on a du faire." (*Eloge de M. de Montesquieu.*) According to the most obvious interpretation of his words, they convey a meaning which I conceive to be the very reverse of the truth.

haustible and unthought-of resources to the student of Jurisprudence, he indirectly marked out to the legislator the extent and the limits of his power, and recalled the attention of the philosopher from abstract and useless theories, to the only authentic monuments of the history of mankind.[1]

This view of law, which unites History and Philosophy with Jurisprudence, has been followed out with remarkable success by various authors since Montesquieu's time; and for a considerable number of years after the publication of the *Spirit of Laws*, became so very fashionable (particularly in this country), that many seem to have considered it, *not* as a step towards a farther end, but as exhausting the whole science of Jurisprudence. For such a conclusion there is undoubtedly some foundation, so long as we confine our attention to the ruder periods of society, in which governments and laws may be universally regarded as the gradual result of time and experience, of circumstances and emergencies. In enlightened ages, however, there cannot be a doubt, that political wisdom comes in for its share in the administration of human affairs; and there is reasonable ground for hoping, that its influence will continue to increase, in proportion as the principles of legislation are more generally studied and understood. To suppose the contrary, would reduce us to be mere *spectators* of the progress and decline of society, and put an end to every species of patriotic exertion.

Montesquieu's own aim in his historical disquisitions, was obviously much more deep and refined. In various instances, one would almost think he had in his mind the very shrewd aphorism of Lord Coke, that, "to trace an error to its fountain-head, is to refute it;"—a species of refutation, which, as Mr Bentham has well remarked, is, with many understandings, the only one that has any weight.[2] To men prepossessed with a blind ve-

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[1] As examples of Montesquieu's peculiar and characteristical style of thinking in *The Spirit of Laws*, may be mentioned his *Observations on the Origin and Revolutions of the Roman Laws on Successions;* and what he has written on the *History of the Civil Laws in his own Country;* above all, his *Theory of the Feudal Laws among the Franks*, considered in relation to the revolutions of their monarchy. On many points connected with these researches, his conclusions have been since controverted; but all his successors have agreed in acknowledging *him* as their common master and guide.

[2] "*If our ancestors have been all along under a mistake, how came they to have fallen into it?* is a question that naturally occurs upon all such occasions. The case is, that, in matters of law more especially, such is the dominion of authority over our minds, and such the prejudice it creates in favour of whatever institution it has taken under its wing, that, after all manner of reasons that can be thought of in favour of the institution have been shewn to be insufficient, we still cannot forbear looking to some unassignable and latent reason for its efficient cause. But if, instead of any such reason, we can find a cause for it in some notion, of the erroneousness of which we are already satisfied, then at last we are content to give it up without further struggle; and then, and not till then, our satisfaction is complete." *Defence of Usury*, pp. 94, 95.

neration for the wisdom of antiquity, and strongly impressed with a conviction that everything they see around them is the result of the legislative wisdom of their ancestors, the very existence of a legal principle, or of an established custom, becomes an argument in its favour; and an argument to which no reply can be made, but by tracing it to some acknowledged prejudice, or to a form of society so different from that existing at present, that the same considerations which serve to account for its first origin, demonstrate indirectly the expediency of now accommodating it to the actual circumstances of mankind.

According to this view of the subject, the speculations of Montesquieu were ultimately directed to the same practical conclusion with that pointed out in the prophetic suggestions of Bacon; aiming, however, at this object, by a process more circuitous; and, perhaps, on that account, the more likely to be effectual. The plans of both have been since combined with extraordinary sagacity, by some of the later writers on Political Economy; [1] but with *their* systems we have no concern in the present section. I shall therefore only remark, in addition to the foregoing observations, the peculiar utility of these researches concerning the *history* of laws, in repressing the folly of sudden and violent innovation, by illustrating the reference which laws must necessarily have to the actual circumstances of a people,—and the tendency which natural causes have to improve gradually and progressively the condition of mankind, under every government which allows them to enjoy the blessings of peace and of liberty.

The well-merited popularity of the *Spirit of Laws*, gave the first fatal blow to the study of *Natural Jurisprudence;* partly by the proofs which, in every page, the work afforded, of the absurdity of all schemes of Universal Legislation; and partly by the attractions which it possessed, in point of eloquence and taste, when contrasted with the insupportable dulness of the systems then in possession of the schools. It is remarkable, that Montesquieu has never once mentioned the name of Grotius;—in *this*, probably, as in numberless other instances, conceiving it to be less expedient to attack established prejudices openly and in front, than gradually to undermine the unsuspected errors upon which they rest.

If the foregoing details should appear tedious to some of my readers, I must request

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[1] Above all, by Mr Smith; who, in his *Wealth of Nations*, has judiciously and skilfully combined with the investigation of general principles, the most luminous sketches of *Theoretical History* relative to that form of political society, which has given birth to so many of the institutions and customs peculiar to modern Europe.—"The strong ray of philosophic light on this interesting subject," which, according to Gibbon, "broke from Scotland in our times," was but a *reflection*, though with a far steadier and more concentrated force, from the scattered but brilliant sparks kindled by the genius of Montesquieu. I shall afterwards have occasion to take notice of the mighty influence which his writings have had on the subsequent history of Scotish literature.

them to recollect, that they relate to a science which, for much more than a hundred years, constituted the whole philosophy, both ethical and political, of the largest portion of civilized Europe. With respect to Germany, in particular, it appears from the Count de Hertzberg, that this science continued to maintain its undisputed ground, till it was supplanted by that growing passion for Statistical details, which, of late, has given a direction so different, and in some respects so opposite, to the studies of his countrymen.[1]

When from Germany we turn our eyes to the south of Europe, the prospect seems not merely sterile, but afflicting and almost hopeless. Of Spanish literature I know nothing but through the medium of Translations; a very imperfect one, undoubtedly, when a judgment is to be passed on compositions addressed to the powers of imagination and taste; yet fully sufficient to enable us to form an estimate of works which treat of science and philosophy. On such subjects, it may be safely concluded, that whatever is unfit to stand the test of a literal version, is not worth the trouble of being studied in the original. The progress of the Mind in Spain during the seventeenth century, we may therefore confidently pronounce, if not entirely suspended, to have been too inconsiderable to merit attention.

"The only good book," says Montesquieu, "which the Spaniards have to boast of, is that which exposes the absurdity of all the rest." In this remark, I have little doubt that there is a considerable sacrifice of truth to the pointed effect of an antithesis. The unqualified censure, at the same time, of this great man, is not unworthy of notice, as a strong expression of his feelings with respect to the general insignificance of the Spanish writers.

The inimitable work here referred to by Montesquieu, is itself entitled to a place in this Discourse, not only as one of the happiest and most wonderful creations of Human fancy, but as the record of a force of character, and an enlargement of mind, which, when contrasted with the prejudices of the author's age and nation, seem almost miraculous. It is not merely against Books of Chivalry that the satire of Cervantes is directed. Many other follies and absurdities of a less local and temporary nature have their share in his ridicule; while not a single expression escapes his pen that can give offence to

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[1] "La connoissance des états qu'on se plait aujourd'hui d'appeller *Statistique*, est une de ces sciences qui sont devenues à la mode, et qui ont pris une vogue générale depuis quelques années; elle a presque dépossédé celle du Droit Public, qui régnoit au commencement et jusques vers le milieu du siècle présent." *Reflexions sur la Force des Etats.* Par M. le Comte de Hertzberg. Berlin, 1782.

the most fastidious moralist. Hence those amusing and interesting contrasts by which Cervantes so powerfully attaches us to the hero of his story; chastising the wildest freaks of a disordered imagination, by a stateliness yet courtesy of virtue, and (on all subjects but one) by a superiority of good sense and of philosophical refinement, which, even under the most ludicrous circumstances, never cease to command our respect and to keep alive our sympathy.

In Italy, notwithstanding the persecution undergone by Galileo, physics and astronomy continued to be cultivated with success by Torricelli, Borelli, Cassini, and others; and in pure geometry, Viviani rose to the very first eminence, as the Restorer, or rather as the Diviner of ancient discoveries; but, in all those studies which require the animating spirit of civil and religious liberty, this once renowned country exhibited the most melancholy symptoms of mental decrepitude. "Rome," says a French historian, "was too much interested in maintaining her principles, not to raise every imaginable barrier against what might destroy them. Hence that *index* of prohibited books, into which were put the history of the President de Thou; the works on the liberties of the Gallican church; and (who could have believed it?) the translations of the Holy Scriptures. Meanwhile, this tribunal, though always ready to condemn judicious authors upon frivolous suspicions of heresy, approved those seditious and fanatical theologists, whose writings tended to the encouragement of regicide, and the destruction of government. The approbation and censure of books (it is justly added) deserve a place in the history of the human mind."

The great glory of the Continent towards the end of the seventeenth century (I except only the philosophers of France) was Leibnitz. He was born as early as 1646; and distinguished himself, while still a very young man, by a display of those talents which were afterwards to contend with the united powers of Clarke and of Newton. I have already introduced his name among the writers on Natural Law; but, in every other respect, he ranks more fitly with the contemporaries of his old age than with those of his youth. My reasons for thinking so will appear in the sequel. In the meantime, it may suffice to remark, that Leibnitz, the Jurist, belongs to one century, and Leibnitz, the Philosopher, to another.

In this, and other analogous distributions of my materials, as well as in the order I have followed in the arrangement of particular facts, it may be proper, once for all, to observe, that much must necessarily be left to the *discretionary*, though not to the *arbitrary* decision of the author's judgment;—that the dates which separate from each other the different stages in the progress of Human Reason, do not, like those which occur in the history of the exact sciences, admit of being fixed with chronological and indisputable precision;

while, in adjusting the perplexed rights of the innumerable claimants in this intellectual and shadowy region, a task is imposed on the writer, resembling not unfrequently the labour of *him*, who should have attempted to circumscribe, by mathematical lines, the melting and intermingling colours of Arachne's web;

> In quo diversi niteant cum mille colores,
> Transitus ipse tamen spectantia lumina fallunt,
> Usque adeo quod tangit idem est, tamen ultima distant.

But I will not add to the number (already too great) of the foregoing pages, by anticipating, and attempting to obviate, the criticisms to which they may be liable. Nor will I dissemble the confidence with which, amid a variety of doubts and misgivings, I look forward to the candid indulgence of those who are best fitted to appreciate the difficulties of my undertaking. I am certainly not prepared to say with Johnson, that "I dismiss my work with frigid indifference, and that to me success and miscarriage are empty sounds." My feelings are more in unison with those expressed by the same writer in the conclusion of the admirable preface to his edition of Shakespeare. One of his reflections, more particularly, falls in so completely with the train of my own thoughts, that I cannot forbear, before laying down the pen, to offer it to the consideration of my readers.

"Perhaps I may not be more censured for doing wrong, than for doing little; for raising in the public, expectations which at last I have not answered. The expectation of ignorance is indefinite, and that of knowledge is often tyrannical. It is hard to satisfy those who know not what to demand, or those who demand by design what they think impossible to be done."

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# NOTES AND ILLUSTRATIONS.

The chief purpose of these Notes and Illustrations, is to verify some of the more important views contained in the foregoing Historical Sketch. The errors into which I have frequently been led by trusting to the information of writers, who, in describing philosophical systems, profess to give merely the general results of their researches, unauthenticated by particular references to the original sources, have long convinced me of the propriety, on such occasions, of bringing under the eye of the reader, the specific authorities on which my statements proceed. Without such a check, the most faithful historian is perpetually liable to the suspicion of accommodating facts to his favourite theories; or of unconsciously blending with the opinions he ascribes to others, the glosses of his own imagination. The quotations in the following pages, selected principally from books not now in general circulation, may, I hope, at the same time, be useful in facilitating the labours of those who shall hereafter resume the same subject, on a scale more susceptible of the minuteness of literary detail.

For a few short biographical digressions, with which I have endeavoured to give somewhat of interest and relief to the abstract and unattractive topics which occupy so great a part of my Discourse, I flatter myself that no apology is necessary; more especially, as these digressions will, in general, be found to throw some additional light on the philosophical or the political principles of the individuals to whom they relate.

## Note A, p. 22.

Sir Thomas More, though, towards the close of his life, he became "a persecutor even unto blood, defiling with cruelties those hands which were never polluted with bribes,"[1] was, in his earlier and better days, eminently distinguished by the humanity of his temper, and the liberality of his opinions. Abundant proofs of this may be collected from his letters to Erasmus; and from the sentiments, both religious and political, indirectly inculcated in his *Utopia*. In contempt for the ignorance and profligacy of the monks, he was not surpassed by his correspondent; and against various superstitions of the Romish church, such as the celibacy of priests, and the use of images in worship, he has expressed himself more decidedly than could well have been expected from a man placed in his circumstances. But *these* were not the whole of his merits. His ideas on Criminal Law are still quoted with respect by the advocates for a milder code than has yet been introduced into this country; and, on the subject of toleration, no modern politician has gone farther than his Utopian Legislators.

1 Burnet.

The disorders occasioned by the rapid progress of the Reformation, having completely shaken his faith in the sanguine speculations of his youth, seem at length, by alarming his fears as to the fate of existing establishments, to have unhinged his understanding, and perverted his moral feelings. The case was somewhat the same with his friend Erasmus, who (as Jortin remarks) "began in his old days to act the zealot and the missionary with an ill grace, and to maintain, that there were *certain* heretics, who might be put to death as blasphemers and rioters." (pp. 428, 481). In the mind of Erasmus, other motives, it is not improbable, concurred; his biographer and apologist being forced to acknowledge that "he was afraid lest Francis, and Charles, and Ferdinand, and George, and Henry VIII., and other persecuting princes, should suspect that he condemned their cruel conduct." Ibid. p. 481.

Something, it must at the same time be observed, may be alleged in behalf of these two illustrious persons; *not*, indeed, in extenuation of their unpardonable defection from the cause of religious liberty, but of their estrangement from some of their old friends, who scrupled not to consider, as apostates and traitors, all those who, while they acknowledged the expediency of ecclesiastical reform, did not approve of the violent measures employed for the accomplishment of that object. A very able and candid argument on this point may be found in Bayle, Article *Castellan*, Note Q.

### Note B, p. 24.

The following short extract will serve to convey a general idea of Calvin's argument upon the subject of usury.

"Pecunia non parit pecuniam. Quid mare? quid domus, ex cujus locatione pensionem percipio? an ex tectis et parietibus argentum proprie nascitur? Sed et terra producit, et mari advehitur quod pecuniam deinde producat, et habitationis commoditas cum certa pecunia parari commutarive solet. Quod si igitur plus ex negotiatione lucri percipi possit, quam ex fundi cujusvis proventu: an feretur qui fundum sterilem fortasse colono locaverit ex quo mercedem vel proventum recipiat sibi, qui ex pecunia fructum aliquem perceperit, non feretur? et qui pecunia fundum acquirit, annon pecunia illa generat alteram annuam pecuniam? Unde vero mercatoris lucrum? Ex ipsius, inquies, diligentia atque industria. Quis dubitat pecuniam vacuam inutilem omnino esse? neque qui à me mutuam rogat, vacuam apud se habere à me acceptam cogitat. Non ergo ex pecunia illa lucrum accedit, sed ex proventu. Illæ igitur rationes subtiles quidem sunt, et speciem quandam habent, sed ubi propius expenduntur, reipsa concidunt. Nunc igitur concludo, judicandum de usuris esse, non ex particulari aliquo Scripturæ loco, sed tantum ex æquitatis regula." *Calvini Epistolæ.*

### Note C, p. 34.

The prevailing idea among Machiavel's contemporaries and immediate successors certainly was, that the design of *the Prince* was hostile to the rights of mankind; and that the author was either entirely unprincipled, or adapted his professed opinions to the varying circumstances of his own eventful life. The following are the words of Bodinus, born in 1530, the very year when Machiavel died; an author whose judgment will have no small weight with those who are acquainted with his political writings: "Machiavel s'est bien fort mesconté, de dire que l'estat populaire est le meilleur:[1] et néantmoins ayant oublié sa première opinion, il a tenu en un autre lieu,[2] que pour restituer l'Italie

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[1] *Discourses upon Livy.*

[2] *Prince*, Book i. c. ix.

en sa liberté, il faut qu'il n'y ait qu'un Prince; et de fait, il s'est efforcé de former un éstat le plus tyrannique du monde; et en autre lieu [1] il confesse, que l'éstat de Venice est le plus beau de tous, lequel est une pure Aristocratie, s'il en fût onques: tellement qu'il ne sçait à quoi se tenir." (*De la République*, Liv. vi. chap. iv. Paris, 1576.) In the Latin version of the above passage, the author applies to Machiavel the phrase, *Homo levissimus ac nequissimus.*

One of the earliest apologists for Machiavel was Albericus Gentilis, an Italian author of whom some account will be given afterwards. His words are these: "Machiavel, a warm panegyrist and keen assertor of democracy; born, educated, promoted under a republican government, was in the highest possible degree hostile to tyranny. The scope of his work, accordingly, is not to instruct tyrants; but, on the contrary, by disclosing their secrets to their oppressed subjects, to expose them to public view, stripped of all their trappings." He afterwards adds, that "Machiavel's real design was, under the mask of giving lessons to sovereigns, to open the eyes of the people; and that he assumed this mask in the hope of thereby securing a freer circulation to his doctrines." (*De Legationibus*, Lib. iii. c. ix. Lond. 1585.) The same idea was afterwards adopted and zealously contended for by Wicquefort, the author of a noted book entitled the *Ambassador*; and by many other writers of a later date. Bayle, in his *Dictionary*, has stated ably and impartially the arguments on both sides of the question; evidently leaning however very decidedly, in his own opinion, to that of Machiavel's Apologists.

The following passage from the excellent work of M. Simonde de Sismondi on the Literature of the South, appears to me to approach very near to the truth in the estimate it contains both of the spirit of the *Prince*, and of the character of the author. "The real object of Machiavel cannot have been to confirm upon the throne a tyrant whom he detested, and against whom he had already conspired; nor is it more probable that he had a design to expose to the people the maxims of tyranny, in order to render them odious. Universal experience made them at that time sufficiently known to all Italy; and that infernal policy which Machiavel reduced to principles, was, in the sixteenth century, practised by every government. There is rather, in his manner of treating it, a universal bitterness against mankind; a contempt of the whole human race; which makes him address them in the language to which they had debased themselves. He speaks to the interests of men, and to their selfish calculations, as if he thought it useless to appeal to their enthusiasm or to their moral feelings."

I agree perfectly with M. de Sismondi in considering the two opposite hypotheses referred to in the above extract, as alike untenable; and have only to add to his remarks, that, in writing the *Prince*, the author seems to have been more under the influence of spleen, of ill-humour, and of blasted hopes, than of any deliberate or systematical purpose, either favourable or adverse to human happiness. The prevailing sentiment in his mind probably was, *Si populus vult decipi, decipiatur.* [2]

According to this view of the subject, Machiavel's *Prince*, instead of being considered as a new system of political morality, invented by himself, ought to be regarded merely as a digest of the maxims of state policy then universally acted upon in the Italian courts. If I be not mistaken, it was in this light that the book was regarded by Lord Bacon, whose opinion concerning it being, in *one* instance, somewhat ambiguously expressed, has been supposed by several writers of note (particularly Bayle and Mr Roscoe) to have coincided with that quoted above from Albericus Gentilis. To me it appears, that the very turn of the sentence appealed to on this occasion is rather disrespectful than otherwise to Machiavel's character. "Est itaque quod gratias agamus Machiavellio et *hujusmodi scrip-*

1 *Discourses upon Livy.*

2 Many traces of this misanthropic disposition occur in the historical and even in the dramatic works of Machiavel. It is very justly observed by M. de Sismondi, that "the pleasantry of his comedies is almost always mingled with gall. His laughter at the human race is but the laughter of contempt."

*toribus*, qui aperte et indissimulanter proferunt, quid homines facere soleant, non quid debeant." (*De Aug. Scient.* Lib. vii. cap. ii.) The best comment, however, on these words, is to be found in another passage of Bacon, where he has expressed his opinion of Machiavel's moral demerits in terms as strong and unequivocal as language can furnish. " Quod enim ad *malas artes* attinet; si quis Machiavellio se dederit in disciplinam; qui præcipit," &c. &c. &c. See the rest of the paragraph (*De Aug. Scient.* Lib. viii. cap. ii.) See also a passage in Book vii. chap. viii. beginning thus: " An non et hoc verum est, juvenes multo minus *Politicæ* quam *Ethicæ* auditores idoneos esse, antequam religione et doctrina de moribus et officiis plene imbuantur; ne forte judicio depravati et corrupti, in eam opinionem veniant, non esse rerum differentias morales veras et solidas, sed omnia ex utilitate.—Sic enim Machiavellio dicere placet, *Quod si contigisset Cæsarem bello superatum fuisse, Catilina ipso fuisset odiosior*," &c. &c. After these explicit and repeated declarations of his sentiments on this point, it is hard that Bacon should have been numbered among the apologists of Machiavel, by such high authorities as Bayle, and the excellent biographer of Lorenzo de Medicis.

## Note D, p. 41.

The charge of plagiarism from Bodin has been urged somewhat indelicately against Montesquieu, by a very respectable writer, the Chevalier de Filangieri. " On a cru, et l'on croit peut-être encore, que Montesquieu, a parlé le premier de l'influence du climat. Cette opinion est une erreur. Avant lui, le délicat et ingénieux Fontenelle s'étoit exercé sur set objet. Machiavel, en plusieurs endroits de ses ouvrages, parle aussi de cette influence du climat sur le physique et sur le moral des peuples. Chardin, un de ces voyageurs qui savent observer, a fait beaucoup de réflexions sur l'influence physique et moral des climats. L'Abbé Dubos a soutenu et développé les pensées de Chardin; et Bodin, qui peut-être avoit lu dans Polybe que le climat détermine les formes, la couleur, et les mœurs des peuples, en avoit déja fait, cent cinquante ans auparavant, la base de son systême, dans son livre de la République, et dans sa Méthode de l'Histoire. Avant tous ces ecrivains, l'immortel Hippocrate avoit traité fort au long cette matière dans son fameux ouvrage *de l'air, des eaux, et des lieux*. L'Auteur de l'Esprit des Lois, sans citer un seul de ces philosophes, établit à son tour un systême; mais il ne fit qu'altérer les principes d'Hippocrate, et donner une plus grande extension aux idées de Dubos, de Chardin, et de Bodin. Il voulut faire croire au public qu'il avoit eu le premier quelques idées sur ce sujet; et le public l'en crut sur sa parole." *La Science de la Législation, ouvrage traduit de l'Italien.* Paris, 1786. Tom. I. pp. 225, 226.

The enumeration here given of writers whose works are in everybody's hands, might have satisfied Filangieri, that, in giving his sanction to this old theory, Montesquieu had no wish to claim to himself the praise of originality. It is surprising, that, in the foregoing list, the name of Plato should have been omitted, who concludes his fifth book, *De Legibus*, with remarking, that " all countries are not equally susceptible of the same sort of discipline; and that a wise legislator will pay a due regard to the diversity of national character, arising from the influence of climate and of soil." It is not less surprising, that the name of Charron should have been overlooked, whose observations on the moral influence of physical causes, discover as much originality of thought as those of any of his successors. See *De la Sagesse*, Livre i. chap. xxxvii.

## Note E, p. 44.

Innumerable instances of Luther's credulity and superstition are to be found in a book entitled *Martini Lutheri Colloquia Mensalia, &c.* first published (according to Bayle) in 1571. The only

copy of it which I have seen, is a translation from the German into the English tongue by Captain Henrie Bell. (London 1652.) This work, in which are "gathered up the fragments of the divine discourses which Luther held at his table with Philip Melanchthon, and divers other learned men," bears to have been originally collected "out of his holy mouth" by Dr Anthony Lauterbach, and to have been afterwards "digested into common-places" by Dr Aurifaber. Although not sanctioned with Luther's name, I do not know that the slightest doubts of its details have been suggested, even by such of his followers as have regretted the indiscreet communication to the public, of his unreserved *table-talk* with his confidential companions. The very accurate Seckendorff has not called in question its authenticity; but, on the contrary, gives it his indirect sanction, by remarking, that it was collected with little prudence, and not less imprudently printed: "Libro *Colloquiorum Mensalium* minus quidem cautè composito et vulgato." (Bayle, Article Luther, Note L.) It is very often quoted as an authority by the candid and judicious Dr Jortin.

In confirmation of what I have said of Luther's credulity, I shall transcribe, in the words of the English translator, the substance of one of Luther's *Divine Discourses*, "concerning the devil and his works." "The devil (said Luther) can transform himself into the shape of a man or a woman, and so deceiveth people; insomuch that one thinketh he lieth by a right woman, and yet is no such matter; for, as St Paul saith, the devil is strong by the child of unbelief. But inasmuch as children or devils are conceived in such sort, the same are very horrible and fearful examples. Like unto this it is also with what they call the *Nix* in the water, who draweth people unto him as maids and virgins, of whom he begetteth devils' children. The devil can also steal children away; as sometimes children within the space of six weeks after their birth are lost, and other children called *suppositititii*, or changelings, laid in their places. Of the Saxons they were called *Killcrops*.

"Eight years since," said Luther, "at *Dessau*, I did see and touch such a changed child, which was twelve years of age; he had his eyes, and all members, like another child; he did nothing but feed, and would eat as much as two clowns were able to eat. I told the Prince of Anhalt, if I were prince of that country, I would venture *homicidium* thereon, and would throw it into the river Moldaw. I admonished the people dwelling in that place devoutly to pray to God to take away the devil. The same was done accordingly, and the second year after the changeling died.

"In Saxony, near unto Halberstad, was a man that also had a *killcrop*, who sucked the mother and five other women dry, and besides devoured very much. This man was advised that he should, in his pilgrimage at Halberstad, make a promise of the *killcrop* to the Virgin Marie, and should cause him there to be rocked. This advice the man followed, and carried the changeling thither in a basket. But going over a river, being upon the bridge, another devil that was below in the river, called and said, *Killcrop! Killcrop!* Then the child in the basket (which never before spake one word), answered, Ho, ho. The devil in the water asked further, Whither art thou going? The child in the basket said, I am going towards Hocklestad to our loving mother, to be rocked. The man being much affrighted thereat, threw the child, with the basket, over the bridge into the water. Whereupon the two devils flew away together, and cried Ho, ho, ha, tumbling themselves over one another, and so vanished." (pp. 386, 387.)

With respect to Luther's Theological Disputes with the Devil, see the passages quoted by Bayle, Art. *Luther*, Note U.

Facts of this sort, so recent in their date, and connected with the history of so great a character, are consolatory to those, who, amid the follies and extravagancies of their contemporaries, are sometimes tempted to despair of the cause of truth, and of the gradual progress of human reason.

## Note F, p. 59.

Ben Jonson is one of the few contemporary writers by whom the transcendent genius of Bacon appears to have been justly appreciated; and the only one I know of, who has transmitted any idea of his forensic eloquence; a subject on which, from his own professional pursuits, combined with the reflecting and philosophical cast of his mind, Jonson was peculiarly qualified to form a competent judgment. "There happened," says he, "in my time, one noble speaker, who was full of gravity in his speaking. No man ever spoke more neatly, more pressly, more weightily, or suffered less emptiness, less idleness in what he uttered. No member of his speech but consisted of its own graces. His hearers could not cough, or look aside from him without loss. He commanded where he spoke, and had his judges angry and pleased at his devotion. The fear of every man that heard him was, that he should make an end." No finer description of the perfection of this art is to be found in any author, ancient or modern.

The admiration of Jonson for Bacon (whom he appears to have known intimately)[1] seems almost to have blinded him to those indelible shades in his fame, to which, even at this distance of time, it is impossible to turn the eye without feelings of sorrow and humiliation. Yet it is but candid to conclude, from the posthumous praise lavished on him by Jonson and by Sir Kenelm Digby,[2] that the servility of the courtier, and the laxity of the judge, were, in the relations of private life, redeemed by many estimable and amiable qualities. That man must surely have been marked by some rare features of moral as well as of intellectual greatness, of whom, long after his death, Jonson could write in the following words.

"My conceit of his person was never increased toward him by his place or honours; but I have and do reverence him, for the greatness that was only proper to himself, in that he seemed to me ever, by his works, one of the greatest men, and most worthy of admiration, that had been in many ages. In his adversity, I ever prayed that God would give him strength, for greatness he could not want. Neither could I condole in a word or syllable for him, as knowing no accident could do harm to virtue, but rather help to make it manifest."

In Aubrey's anecdotes of Bacon,[3] there are several particulars not unworthy of the attention of his future biographers. *One* expression of this writer is more peculiarly striking: "In short, all that were *great and good* loved and honoured him." When it is considered, that Aubrey's knowledge of Bacon was derived chiefly through the medium of Hobbes, who had lived in habits of the most intimate friendship with both, and whose writings shew that he was far from being an idolatrous admirer of Bacon's philosophy, it seems impossible for a candid mind, after reading the foregoing short but comprehensive eulogy, not to feel a strong inclination to dwell rather on the fair than on the dark side of the Chancellor's character, and, before pronouncing an unqualified condemnation, carefully to separate the faults of the age from those of the individual.

An affecting allusion of his own, in one of his greatest works, to the errors and misfortunes of his public life, if it does not atone for his faults, may, at least, have some effect in softening the asperity

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1 Jonson is said to have translated into Latin great part of the books *De Augmentis Scientiarum*. Dr Warton states this (I do not know on what authority) as an undoubted fact. *Essay on the Genius and Writings of Pope.*

2 See his letters to M. de Fermat, printed at the end of Fermat's *Opera Mathematica*, Tolosæ, 1679.

3 Lately published in the extracts from the Bodleian library.

of our censures. "Ad literas potius quam ad aliud quicquam natus, et ad res gerendas nescio quo fato contra genium suum abreptus." *De Aug. Sc.* L. viii. c. iii.

Even in Bacon's professional line, it is now admitted, by the best judges, that he was greatly underrated by his contemporaries. "The Queen did acknowledge," says the Earl of Essex, in a letter to Bacon himself, "you had a great wit, and an excellent gift of speech, and much other good learning. But *in law*, she rather thought you could make shew, to the utmost of your knowledge, than that you were deep."

"If it be asked," says Dr Hurd, "how the Queen came to form this conclusion, the answer is plain. It was from Mr Bacon's having a great wit, an excellent gift of speech, and much other good learning." Hurd's *Dialogues*.

The following testimony to Bacon's legal knowledge (pointed out to me by a learned friend) is of somewhat more weight than Queen Elizabeth's judgment against it: "What might we not have expected," says Mr Hargrave, after a high encomium on the powers displayed by Bacon in his 'Reading on *the Statute of Uses*,' "what might we not have expected from the hands of such a master, if his vast mind had not so embraced within its compass the whole field of science, as very much to detach him from professional studies!"

It was probably owing in part to his court-disgrace, that so little notice was taken of Bacon, for some time after his death, by those English writers who availed themselves, without any scruple, of the lights struck out in his works. A very remarkable example of this occurs in a curious, though now almost forgotten book (published in 1627), entitled, *An Apology or Declaration of the Power and Providence of God in the Government of the World*, by George Hakewill, D. D. Archdeacon of Surrey. It is plainly the production of an uncommonly liberal and enlightened mind; well stored with various and choice learning, collected both from ancient and modern authors. Its general aim may be guessed at from the text of Scripture prefixed to it as a motto, "Say not thou, what is the cause that the former days are better than these, for thou dost not inquire wisely concerning this;" and from the words of Ovid, so happily applied by Hakewill to the "common error touching the golden age,"

> Prisca juvent alios, ego me nunc denique natum
> Gratulor.

That the general design of the book, as well as many incidental observations contained in it, was borrowed from Bacon, there cannot, I apprehend, be a doubt; and yet I do not recollect more than one or two references (and these very slight ones) to his writings, through the whole volume. One would naturally have expected, that, in the following passage of the epistle dedicatory, the name of the late unfortunate Chancellor of England, who had died in the course of the preceding year, might have found a place along with the other *great clerks* there enumerated: "I do not believe that all regions of the world, or all ages in the same region, afford wits always alike; but *this* I think (neither is it my opinion alone, but of Scaliger, Vives, Budæus, Bodin, and other *great clerks*), that the wits of these latter ages, being manured by industry, directed by precepts, and regulated by method, may be as capable of deep speculations, and produce as masculine and lasting births, as any of the ancienter times have done. But if we conceive them to be giants, and ourselves dwarfs; if we imagine all sciences already to have received their utmost perfection, so as we need not but translate and comment on what they have done, surely there is little hope that we should ever come near them, much less match them. The first step to enable a man to the achieving of great designs, is to be persuaded that he is able to achieve them; the next not to be persuaded, that whatsoever hath not yet been done, cannot therefore *be* done. Not any one man, or nation, or age, but rather *mankind* is it, which, in latitude of capacity, answers to the universality of things to be known." In another passage, Hakewill

observes, that, "if we will speak properly and punctually, antiquity rather consists in the old age, than in the infancy or youth of the world." I need scarcely add, that some of the foregoing sentences are almost literal transcripts of Bacon's words.

The philosophical fame of Bacon in his own country may be dated from the establishment of the Royal Society of London; by the founders of which, as appears from their colleague, Dr Sprat, he was held in so high estimation, that it was once proposed to prefix to the history of their labours some of Bacon's writings, as the best comment on the views with which they were undertaken. Sprat himself, and his illustrious friend Cowley, were among the number of Bacon's earliest eulogists; the latter, in an Ode to the Royal Society, too well known to require any notice here; the former, in a very splendid passage of his History, from which I shall borrow a few sentences, as a conclusion and ornament to this note.

"For, is it not wonderful, that he who had run through all the degrees of that profession, which usually takes up men's whole time; who had studied, and practised, and governed the common law; who had always lived in the crowd, and borne the greatest burden of civil business; should yet find leisure enough for these retired studies, to excel all those men, who separate themselves for this very purpose? He was a man of strong, clear, and powerful imaginations; his genius was searching and inimitable; and of this I need give no other proof than his style itself; which as, for the most part, it describes men's minds, as well as pictures do their bodies, so it did his above all men living. The course of it vigorous and majestical; the wit bold and familiar; the comparisons fetched out of the way, and yet the more easy:[1] In all expressing a soul equally skilled in men and nature."

## Note G, p. 62.

The paradoxical bias of Hobbes's understanding is never so conspicuous as when he engages in physical or in mathematical discussions. On such occasions, he expresses himself with even more than his usual confidence and arrogance. Of the Royal Society (*the Virtuosi*, as he calls them, *that meet at Gresham College*) he writes thus: "Conveniant, studia conferant, experimenta faciant quantum volunt, nisi et principiis utantar meis, nihil proficient." And elsewhere: "Ad causas autem propter quas proficere ne paullum quidem potuistis nec poteritis, accedunt etiam alia, ut odium Hobbii, quia nimium libere scripserat de academiis veritatem: Nam ex eo tempore irati physici et mathematici veritatem ab eo venientem non recepturos se palam professi sunt." In his English publications, he indulges in a vein of coarse scurrility, of which his own words alone can convey any idea. "So go your ways," says he, addressing himself to Dr Wallis and Dr Seth Ward, two of the most eminent mathematicians then in England, "you uncivil ecclesiastics, inhuman divines, de-doctors of morality, unasinous colleagues, egregious pair of *Issachars*, most wretched *indices and vindices academiarum*; and remember Vespasian's law, *that it is unlawful to give ill language first, but civil and lawful to return it.*"

## Note H, p. 64.

With respect to the *Leviathan*, a very curious anecdote is mentioned by Lord Clarendon. "When I returned," says he, "from Spain by Paris, Mr Hobbes frequently came to me, and told me that his

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1 By the word *easy*, I presume Sprat here means the native and spontaneous growth of Bacon's own fancy, in opposition to the traditionary similies borrowed by common-place writers from their predecessors.

book, which he would call *Leviathan*, was then printing in England, and that he received every week a sheet to correct; and thought it would be finished within a little more than a month. He added, that he knew when I read the book I would not like it; and thereupon mentioned some conclusions; upon which I asked him why he would publish such doctrines; to which, after a discourse between jest and earnest, he said, "*The truth is, I have a mind to go home.*" In another passage, the same writer expresses himself thus: "The review and conclusion of the *Leviathan* is, in truth, a sly address to Cromwell, that, being out of the kingdom, and so being neither conquered nor his subject, he might, by his return, submit to his government, and be bound to obey it. This review and conclusion he made short enough to hope that Cromwell might read it; where he should not only receive the pawn of his new subject's allegiance, by declaring his own obligations and obedience; but by publishing such doctrines as, being diligently infused by such a master in the art of government, might secure the people of the kingdom (over whom he had no right to command) to acquiesce and submit to his brutal power."

That there is no exaggeration or misrepresentation of facts in these passages, with the view of injuring the character of Hobbes, may be confidently presumed from the very honourable testimony which Clarendon bears, in another part of the same work, to his moral as well as intellectual merits. "Mr Hobbes," he observes, "is a man of excellent parts; of great wit; of some reading; and of somewhat more thinking; one who has spent many years in foreign parts and observations; understands the learned as well as modern languages; hath long had the reputation of a great philosopher and mathematician; and in his age hath had conversation with many worthy and extraordinary men. In a word, he is one of the most ancient acquaintance I have in the world, and of whom I have always had a great esteem, as a man, who, besides his eminent learning and knowledge, hath been always looked upon as a man of probity, and of a life free from scandal."

## Note I, p. 89.

It is not easy to conceive how Descartes reconciled, to his own satisfaction, his frequent use of the word *substance*, as applied to the mind, with his favourite doctrine, that the *essence* of the mind consists in *thought*. Nothing can be well imagined more unphilosophical than this last doctrine, in whatever terms it is expressed; but to designate by the name of *substance*, what is also called *thought*, in the course of the same argument, renders the absurdity still more glaring than it would otherwise have been.

I have alluded, in the text, to the difference between the popular and the scholastic notion of *substance*. According to the latter, the word *substance* corresponds to the Greek word *ουσια*, as employed by Aristotle to denote the first of the predicaments; in which technical sense it is said, in the language of the schools, to signify *that* which supports attributes, or which is *subject to accidents*. At a period when every person liberally educated was accustomed to this barbarous jargon, it might not appear altogether absurd to apply the term *substance* to the human soul, or even to the Deity. But, in the present times, a writer who should so employ it may be assured, that, to a great majority of his readers, it will be no less puzzling than it was to Crambe, in Martinus Scriblerus, when he first heard it thus defined by his master Cornelius. [1] How extraordinary does the following sentence now

[1] "When he was told, a *substance* was that which was *subject to accidents*, then soldiers, quoth Crambe, are the most substantial people in the world." Let me add, that, in the list of Philosophical reformers, the authors of Martinus Scriblerus ought not to

sound even to a philosophical ear! and yet it is copied from a work published little more than seventy years ago, by the learned and judicious Gravesande: " Substantiæ sunt aut cogitantes, aut non cogitantes; cogitantes duas novimus, Deum et mentem nostram. Duæ etiam substantiæ, quæ non cogitant, nobis notæ sunt, spatium et corpus." *Introd. ad Phil.* § 19.

The Greek word ουσια (derived from the participle of ειμι) is not liable to these objections. It obtrudes no sensible image on the fancy; and, in this respect, has a great advantage over the Latin word *substantia*. The former, in its logical acceptation, is an extension to Matter, of an idea originally derived from Mind. The latter is an extension to Mind of an idea originally derived from Matter.

Instead of defining *mind* to be a thinking *substance*, it seems much more logically correct to define it a thinking *being*. Perhaps it would be better still, to avoid, by the use of the pronoun *that*, any substantive whatever, " Mind is *that* which thinks, wills," &c.

The foregoing remarks afford me an opportunity of exemplifying what I have elsewhere observed concerning the effects which the scholastic philosophy has left on the present habits of thinking, even of those who never cultivated that branch of learning. In consequence of the stress laid on the *predicaments*, men became accustomed in their youth to imagine, that, in order to know the nature of anything, it was sufficient to know under what *predicament* or *category* it ought to be arranged; and that, till this was done, it remained to our faculties a subject merely of ignorant wonder. Hence the impotent attempt to comprehend under some common name (such as that of *substance*) the heterogeneous existences of *matter*, of *mind*, and even of *empty space*; and hence the endless disputes to which the last of these words has given rise in the Schools.

In our own times, Kant and his followers seem to have thought, that they had thrown a new and strong light on the nature of *space* and also of *time*, when they introduced the word *form (forms of the intellect)* as a common term applicable to both. Is not this to revert to the scholastic folly of verbal generalization? And is it not evident, that of things which are *unique* (such as *matter*, *mind*, *space*, *time)* no classification is practicable? Indeed, to speak of classifying what has nothing in common with anything else, is a contradiction in terms. It was thus that St Augustine felt, when he said, " Quid sit tempus, si nemo quærat a me, scio; si quis interroget, nescio." His idea evidently was, that, although he annexed as clear and precise a notion to the word *time*, as he could do to any object of human thought, he was unable to find any term more general, under which it could be comprehended; and consequently, unable to give any definition, by which it might be explained.

## Note K, p. 89.

" Les Méditations de Descartes parûrent in 1641. C'étoit, de tous ses ouvrages, celui qu'il estimoit le plus. Ce qui characterise sur tout cet ouvrage, c'est qu'il contient sa fameuse démonstration de Dieu par l'idée, démonstration si répétée depuis, adoptée par les uns, et rejettée par les autres; et *qu'il est le premier où la distinction de l'esprit et de la matière soit parfaitement développée*, car avant Descartes on n'avoit encore bien approfondi les preuves philosophiques de la spiritualité de l'ame." *Eloge de Descartes*, par M. Thomas. Note 20.

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be overlooked. Their happy ridicule of the scholastic Logic and Metaphysics are universally known; but few are aware of the acuteness and sagacity displayed in their allusions to some of the most vulnerable passages in Locke's Essay. In this part of the work it is commonly understood that Arbuthnot had the principal share.

If the remarks in the text be correct, the characteristical merits of Descartes' *Meditations* do not consist in the novelty of the proofs contained in them of the *spirituality* of the soul (on which point Descartes has added little or nothing to what had been advanced by his predecessors), but in the clear and decisive arguments by which they expose the absurdity of attempting to explain the mental phenomena, by analogies borrowed from those of matter. Of this distinction, neither Thomas, nor Turgot, nor D'Alembert, nor Condorcet, seem to have been at all aware.

I quote from the last of these writers an additional proof of the confusion of ideas upon this point, still prevalent among the most acute logicians. " Ainsi *la spiritualité de l'ame*, n'est pas une opinion qui ait besoin de preuves, mais le résultat simple et naturel d'une analyse exacte de nos idées, et de nos facultés." (*Vie de M. Turgot.*) Substitute for *spirituality* the word *immateriality*, and the observation becomes equally just and important.

## Note L, p. 90.

The following extract from Descartes might be easily mistaken for a passage in the *Novum Organon.* " Quoniam infantes nati sumus, et varia de rebus sensibilibus judicia prius tulimus, quam integrum nostræ rationis usum haberemus, multis præjudiciis à veri cognitione avertimur, quibus non aliter videmur posse liberari, quam si semel in vitâ, de iis omnibus studeamus dubitare, in quibus vel minimam incertitudinis suspicionem reperiemus.

" Quin et illa etiam, de quibus dubitabimus, utile erit habere pro falsis, ut tanto clarius, quidnam certissimum et cognitu facillimum sit, inveniamus.

" Itaque ad serio philosophandum, veritatemque omnium rerum cognoscibilium indagandam, primò omnia præjudicia sunt deponenda; sive accuratè est cavendum, ne ullis ex opinionibus olim à nobis receptis fidem habeamus, nisi prius, iis ad novum examen revocatis, veras esse comperiamus." *Princ. Phil. Pars Prima*, §§ lii. lxxv.

Notwithstanding these and various other similar coincidences, it has been asserted, with some confidence, that Descartes had never read the works of Bacon. " Quelques auteurs assurent que Descartes n'avoit point lu les ouvrages de Bacon; et il nous dit lui-même dans une de ses lettres, qu'il ne lut que fort tard les principaux ouvrages de Galilée." (*Eloge de Descartes*, par Thomas.) Of the veracity of Descartes, I have not the slightest doubt; and therefore I consider this last fact (however extraordinary) as completely established by his own testimony. But it would require more evidence than the assertions of those nameless writers alluded to by Thomas, to convince me that he had never looked into an author, so highly extolled as Bacon is, in the letters addressed to himself by his illustrious antagonist, Gassendi. At any rate, if this was actually the case, I cannot subscribe to the reflection subjoined to the foregoing quotation by his eloquent eulogist. " Si cela est, il faut convenir, que la gloire de Descartes en est bien plus grande."

## Note M, p. 100.

From the indissoluble union between the notions of colour and of extension, Dr Berkeley has drawn a curious, and, in my opinion, most illogical argument in favour of his scheme of idealism;—which, as it may throw some additional light on the phenomena in question, I shall transcribe in his own words.

" Perhaps, upon a strict inquiry, we shall not find, that even those who, from their birth, have grown up in a continued habit of seeing, are still irrevocably prejudiced on the other side, to wit, in thinking what they see to be at a distance from them. For, at this time, it seems agreed on all hands, that *colours*, which are the proper and immediate objects of sight, are not without the mind. But then, it will be said, by sight we have also the ideas of extension, and figure, and motion; all which may well be thought *without*, and at some distance from the mind, though colour should not. In answer to this, I appeal to any man's experience, whether the visible extension of any object doth not appear *as near* to him as the colour of that object; nay, whether they do not both seem to be in the same place. Is not the extension we see coloured; and is it possible for us, so much as in thought, to separate and abstract colour from extension? Now, where the extension is, there surely is the figure, and there the motion too. I speak of those which are perceived by sight." [1]

Among the multitude of arguments advanced by Berkeley, in support of his favourite theory, I do not recollect any that strikes me more with the appearance of a wilful sophism than the foregoing. It is difficult to conceive, how so very acute a reasoner should not have perceived that his premises, in this instance, lead to a conclusion directly opposite to what he has drawn from them. Supposing all mankind to have an irresistible conviction of the *outness* and distance of extension and figure, it is very easy to explain, from the association of ideas, and from our early habits of inattention to the phenomena of consciousness, how the sensations of colour should appear to the imagination to be transported *out* of the mind. But if, according to Berkeley's doctrines, the constitution of human nature leads men to believe that extension and figure, and every other quality of the material universe, exists only within themselves, whence the ideas of *external* and of *internal*; of *remote*, or of *near?* When Berkeley says, " I appeal to any man's experience, whether the visible extension of any object doth not appear *as near* to him as the colour of that object;" how much more reasonable would it have been to have stated the indisputable fact, that the colour of the object appears as *remote* as its extension and figure? Nothing, in my opinion, can afford a more conclusive proof, that the natural judgment of the mind is against the inference just quoted from Berkeley, than the problem of D'Alembert, which has given occasion to this discussion.

## Note N, p. 104.

It is observed by Dr Reid, that " the system which is now generally received with regard to the mind and its operations, derives not only its spirit from Descartes, but its fundamental principles; and that, after all the improvements made by Malebranche, Locke, Berkeley, and Hume, it may still be called *the Cartesian system.*" *Conclusion of the Inquiry into the Human Mind.*

The part of the Cartesian system here alluded to is the hypothesis, that the communication between the mind and external objects is carried on by means of *ideas* or *images;—not*, indeed, transmitted *from without* (as the Aristotelians supposed) through the channel of the senses, but nevertheless bearing a relation to the qualities perceived, analogous to that of an impression on wax to the seal by which it was stamped. In this last assumption, Aristotle and Descartes agreed perfectly; and the chief difference between them was, that Descartes palliated, or rather kept out of view, the more obvious absurdities of the old theory, by rejecting the unintelligible supposition of *intentional species*, and by substituting, instead of the word *image*, the more indefinite and ambiguous word *idea*.

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1 *Essay toward a New Theory of Vision*, p. 255.

But there was another and very important step made by Descartes, in restricting the ideal Theory to the *primary* qualities of matter; its *secondary* qualities (of colour, sound, smell, taste, heat, and cold) having, according to him, no more *resemblance* to the sensations by means of which they are perceived, than arbitrary sounds have to the things they denote, or the edge of a sword to the pain it may occasion. (*Princ.* Pars iv. §§ 197, 198.) To this doctrine he frequently recurs in other parts of his works.

In these modifications of the Aristotelian Theory of Perception Locke acquiesced entirely; explicitly asserting, that "the *ideas* of *primary* qualities are resemblances of them, but that the *ideas* of secondary qualities have no resemblance to them at all." *Essay*, B. ii. c. viii. § 15.

When pressed by Gassendi to explain how images of extension and figure can exist in an unextended mind, Descartes expresses himself thus: "Quæris quomodo existimem in me subjecto inextenso recipi posse speciem ideamve corporis quod extensum est. Respondeo nullam speciem corpoream in mente recipi, sed puram intellectionem tam rei corporeæ quam incorporeæ fieri absque ulla specie corporeæ; ad imaginationem vero, quæ non nisi de rebus corporeis esse potest, opus quidem esse specie quæ sit verum corpus, et *ad quam mens se applicet*, sed non quæ in mente recipiatur." Responsio de iis quæ in sextam Meditationem objecta sunt, § 4.

In this reply it is manifestly assumed as an indisputable principle, that the immediate objects of our thoughts, when we *imagine* or *conceive* the primary qualities of extension and figure, are *ideas* or *species* of these qualities; and, of consequence, are themselves extended and figured. Had it only occurred to him to apply (*mutatis mutandis*) to the perception of *primary* qualities his own account of the perception of *secondary* qualities (that it is obtained, to wit, by the *media* of sensations more analogous to arbitrary signs, than to stamps or pictures), he might have eluded the difficulty started by Gassendi, without being reduced to the disagreeable necessity of supposing his *ideas* or *images* to exist in the brain, and not in the mind. The language of Mr Locke, it is observable, sometimes implies the one of these hypotheses, and sometimes the other.

It was plainly with the view of escaping from the dilemma proposed by Gassendi to Descartes, that Newton and Clarke were led to adopt a mode of speaking concerning perception, approaching very nearly to the language of Descartes. "Is not," says Newton, "the sensorium of animals the place where the sentient substance *is present*; and to which the sensible *species* of things are brought, through the nerves and brain, that there they may be perceived by the mind *present in that place?*" And still more confidently Dr Clarke: "Without being *present to the images* of the things perceived, the soul could not possibly perceive them. A living substance can only there perceive where it is present. Nothing can any more act or be acted upon *where* it is not present, than it can *when* it is not." The distinction between primary and secondary qualities was afterwards rejected by Berkeley, in the course of his argument against the existence of matter; but he continued to retain the language of Descartes concerning *ideas*, and to consider them as the *immediate*, or rather as the *only* objects of our thoughts, wherever the external senses are concerned. Mr Hume's notions and expressions on the subject are very nearly the same.

I thought it necessary to enter into these details, in order to shew with what limitations the remark quoted from Dr Reid in the beginning of this note ought to be received. It is certainly true, that the Cartesian system may be said to form the ground-work of Locke's Theory of Perception, as well as of the sceptical conclusions deduced from it by Berkeley and Hume; but it is not the less true, that it forms also the ground-work of all that has since been done towards the substitution, in place of this scepticism, of a more solid fabric of metaphysical science.

## Note O, p. 105.

After the pains taken by Descartes to ascertain the *seat* of the soul, it is surprising to find one of the most learned English divines of the seventeenth century (Dr Henry More) accusing him as an abettor of the dangerous heresy of *nullibism*. Of this heresy Dr More represents Descartes as the chief author; and, at the same time, speaks of it as so completely extravagant, that he is at a loss whether to treat it as the serious opinion of a philosopher, or as the jest of a buffoon. "The chief author and leader of the Nullibists," he tells us, "seems to have been *that pleasant wit*, *Renatus Descartes*, who, by his *jocular* metaphysical meditations, has luxated and distorted the rational faculties of some otherwise sober and quick-witted persons." To those who are at all acquainted with the philosophy of Descartes, it is unnecessary to observe, that, so far from being a Nullibist, he valued himself not a little on having fixed the precise *ubi* of the soul, with a degree of accuracy unthought of by any of his predecessors. As he held, however, that the soul was *unextended*, and as More happened to conceive that nothing which was unextended could have any reference to place, he seems to have thought himself entitled to impute to Descartes, in direct opposition to his own words, the latter of these opinions as well as the former. "The true notion of a spirit," according to More, "is that of an extended penetrable substance, logically and intellectually divisible, but not physically discernible into parts."

Whoever has the curiosity to look into the works of this once admired, and, in truth, very able logician, will easily discover that his alarm at the philosophy of Descartes was really occasioned, not by the scheme of *nullibism*, but by the Cartesian doctrine of the *non-extension* of mind, which More thought inconsistent with a fundamental article in his own creed—the existence of witches and apparitions. To hint at any doubt about either, or even to hold any opinion that seemed to weaken their credibility, appeared to this excellent person quite a sufficient proof of complete atheism.

The observations of More on "the true notion of a spirit" (extracted from his *Enchiridion Ethicum*) were afterwards republished in Glanville's book upon witchcraft;—a work (as I before mentioned) proceeding from the same pen with the *Scepsis Scientifica*, one of the most acute and original productions of which English philosophy had then to boast.

If some of the foregoing particulars should, at first sight, appear unworthy of attention in a historical sketch of the progress of science, I must beg leave to remind my readers, that they belong to a history of still higher importance and dignity—that of the progress of Reason, and of the Human Mind.

## Note P, p. 107.

For an interesting sketch of the chief events in the life of Descartes, See the Notes annexed to his Eloge by Thomas; where also is to be found a very pleasing and lively portrait of his moral qualities. As for the distinguishing merits of the Cartesian philosophy, and more particularly of the Cartesian metaphysics, it was a subject peculiarly ill adapted to the pen of this amiable and eloquent, but verbose and declamatory academician.

I am doubtful, too, if Thomas has not gone too far, in the following passage, on a subject of which he was much more competent to judge than of some others which he has ventured to discuss: "L'imagination brillante de Descartes se décèle partout dans ses ouvrages; et s'il n'avoit voulu être ni géométre ni philosophe, il n'auroit tenu qu'à lui d'être le plus bel esprit de son temps." Whatever opinion may be formed on this last assertion, it will not be disputed by those who have studied Descartes, that his *philosophical* style is remarkably dry, concise, and severe. Its great merit lies in its singular precision and perspicuity;—a perspicuity, however, which does not dispense with a moment's relaxation in the reader's attention; the author seldom repeating his remarks, and hardly ever attempting to il-

lustrate or to enforce them either by reasoning or by examples. In all these respects, his style forms a complete contrast to that of Bacon's.

In Descartes' *epistolary* compositions, indeed, ample evidences are to be found of his vivacity and fancy, as well as of his classical taste. One of the most remarkable is a letter addressed to Balzac, in which he gives his reasons for preferring Holland to all other countries, not only as a tranquil, but as an agreeable residence for a Philosopher; and enters into some very engaging details concerning his own petty habits. The praise bestowed on this letter by Thomas is by no means extravagant, when he compares it to the best of Balzac's. " Je ne sçais s'il y a rien dans tout Balzac où il y ait autant d'esprit et d'agrément."

## NOTE Q, p. 111. [1]

It is an error common to by far the greater number of modern metaphysicians, to suppose that there is no medium between the innate ideas of Descartes, and the opposite theory of Gassendi. In a very ingenious and learned essay on Philosophical Prejudices, by M. Trembley, [2] I find the following sentence: " Mais l'expérience dément ce systême des idées inneés, puisque la privation d'un sens emporte avec elle la privation des idées attachées à ce sens, comme l'a remarqué l'illustre auteur de *l'Essai Analytique sur les Facultés de l'Ame*."

What are we to understand by the remark here ascribed to Mr Bonnet? Does it mean nothing more than this, that to a person born blind, no instruction can convey an idea of colours, nor to a person born deaf, of sounds? A remark of this sort surely did not need to be sanctioned by the united names of Bonnet and of Trembley: Nor, indeed, does it bear in the slightest degree on the point in dispute. The question is not about our ideas of the *material* world, but about those ideas on *metaphysical* and *moral* subjects, which may be equally imparted to the blind and to the deaf; enabling them to arrive at the knowledge of the same truths, and exciting in their minds the same moral emotions. The *signs* employed in the reasonings of these two classes of persons will of course excite by association, in their respective fancies, very different *material images*; but whence the origin of the physical and moral *notions* of which these signs are the vehicle, and for suggesting which, *all* sets of signs seem to be equally fitted? The astonishing scientific attainments of many persons, blind from their birth, and the progress lately made in the instruction of the deaf, furnish palpable and incontestible proofs of the flimsiness of this article of the Epicurean philosophy;—so completely verified is now the original and profound conclusion long ago formed by Dalgarno, " That the soul can exert her powers by the ministry of any of the senses: And, therefore, when she is deprived of her principal secretaries, the eye and the ear, then she must be contented with the service of her lackeys and scullions, the other senses; which are no less true and faithful to their mistress than the eye and the ear; but not so quick for dispatch." *Didascalocophus*, &c. Oxford, 1680.

I was once in hopes of being able to throw a still stronger light on the subject of this note, by attempting to ascertain experimentally the possibility of awakening and cultivating the dormant powers of a boy destitute of the organs both of sight and of hearing; but unexpected occurrences have disappointed my expectations.

I have just learned, that a case somewhat similar, though not quite so favourable in all its circumstances, has recently occurred in the state of Connecticut in New England; and I have the satisfaction to add, there is some probability that so rare an opportunity for philosophical observations and experiments will not be overlooked in that quarter of the world.

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1 The reference to this Note was accidentally omitted in the proper place. It ought to have been in page 111, line 21, at the end of the paragraph.

2 *Essai sur les Préjugés*, &c. Neuchatel, 1790.

NOTE R, p. 113.

Of Gassendi's orthodoxy as a Roman Catholic divine, he has left a very curious memorial, in an inaugural discourse pronounced in 1645, before Cardinal Richelieu, when he entered on the duties of his office as Regius Professor of Mathematics at Paris. The great object of the oration is to apologize to his auditors for his having abandoned his ecclesiastical functions, to teach and cultivate the profane science of geometry. With this view, he proposes to explain and illustrate the saying of Plato, who, being questioned about the employment of the Supreme Being, answered, Γεωμετρειν τον θεον. In the prosecution of this argument, he expresses himself thus on the doctrine of the Trinity.

" Anne proinde hoc adorandum Trinitatis mysterium habebimus rursus ut sphæram, cujus quasi centrum sit Pater Æternus, qui totius divinitatis fons, origo, principium accommodatè dicitur; circumferentia Filius, in quo legitur habitare plenitudo Divinitatis; et radii centro circumferentiæque intercedentes Spiritus Sanctus, qui est Patris et Filii nexus, vinculumque mutuum? Anne potius dicendum est eminere in hoc mysterio quicquid sublime magnificumque humana geometria etiamnum requirit? Percelebre est latere eam adhuc, quam quadraturam circuli vocant; atque idcirco in eo esse, ut describat triangulum, cujus si basin ostenderit circuli ambitui æqualem, tum demum esse circulo triangulum æquale demonstrat. At in hoc mysterio augustissimo gloriosissima Personarum Trias ita infinitæ essentiæ, ipsiusque fœcunditati, tanquam circulo exæquatur, seu, ut sic loquar, et veriùs quidem, penitùs identificatur; ut cum sit omnium, et cujusque una, atque eadem essentia, una proinde ac eadem sit immensitas, æternitas, et perfectionum plenitudo.

" Sic, cum nondum nôrit humana geometria trisecare angulum, dividereve, et, citra accommodationem mechanicam, ostendere divisum esse in tria æqualia; habemus in hocce mysterio unam essentiam non tam trisectam, quàm integram communicatam in tria æqualia supposita, quæ cum simul, sigillatimque totam individuamque possideant, sint inter se tamen realiter distincta."

The rest of the oration is composed in exactly the same taste.

The following interesting particulars of Gassendi's death are recorded by Sorbière.

" Extremam tamen horam imminentem sentiens, quod reliquum erat virium impendendum existimavit præparando ad mortem animo. Itaque significavit, ut quamprimum vocaretur Sacerdos, in cujus aurem, dum fari poterat, peccata sua effunderet. . . . . . Dein, ut nihil perfectæ Christiani militis armaturæ deesset, sacro inungi oleo efflagitavit. Ad quam cæremoniam animo attendens, cum sacerdos aures inungens pronuntiaret verba solennia, et lapsu quodam memoriæ dixisset, *Indulgeat tibi Dominus quidquid per odoratum peccasti*, reposuit statim æger, *imo per auditum;* adeo intentus erat rei gravissimæ, et eluendarum sordium vel minimarum cupidum se et sitibundum gerebat." Sorberii Præfatio.

Having mentioned in the text the avowed partiality of Gassendi for the Epicurean ethics, it is but justice to his memory to add, that his own habits were, in every respect, the reverse of those commonly imputed to this school. " Ad privatam Gassendi vitam sæpius attendens," says Sorbière, " anachoretam aliquem cernere mihi videor, qui mediâ in urbe vitam instituit planè ad monachi severioris normam; adeo paupertatem, castitatem et obedientiam coluit; quanquam sine ullo voto tria ista vota solvisse videatur.——Abstemius erat sponte sua, ptisanam tepidam bibens pulmoni refrigerando humectandoque. Carne raro, herbis sæpius, ac maceratâ offâ manè et vesperè utebatur." Ibid.

END OF PART FIRST.

# Supplement

TO THE

# ENCYCLOPÆDIA BRITANNICA.



Abdallatif.

ABDALLATIF, or ABDOLLATIPH, a celebrated physician and traveller, and one of the most voluminous writers of the East, was born at Bagdad, in the 557th year of the Hegira, being the 1161st of the Christian era. Of the life of this learned person, there has fortunately been preserved a memoir, written by himself, together with some additions by a contemporary biographer, named Osaiba. The whole of this curious piece has been lately translated into French, and published with a work of Abdallatif's, of which we shall afterwards give some account. Long before the period of his birth, the splendid empire of the Caliphs had fallen from its meridian greatness; but their capital still continued to enjoy those advantages for education, which it had originally derived from their liberal patronage of learning and science. Abdallatif was carefully instructed in every branch of knowledge then taught in this renowned city; and the biographical piece just alluded to, is not a little interesting, from the glimpses it affords of the kind of studies which engaged the attention of the more aspiring of the Mussulman youth.

After learning to read, the rules of grammar appear to have been studied with a degree of care and earnestness, which has not perhaps been equalled in any other country. With the study of grammar, was joined that of the Koran, and the traditionary doctrines, and the whole of the sacred book was carefully committed to memory. This faculty seems, indeed, to have been severely taxed; for it was also thought necessary to be able to repeat several treatises on grammar and jurisprudence, besides some of the choicer collections of Arabian poetry. In these arduous exercises, Abdallatif says, that he was for a considerable time accustomed to pass the greater part of the night.

Having attained to great proficiency in the usual studies, he afterwards applied to the natural philosophy of that day, and to medicine; and with the view of still farther improving himself by converse with the learned of other places, he set out, when in his twenty-eighth year, to Mosul in Mesopotamia. Having resided about a year in this city, he next proceeded to Damascus, then a place of great resort to the learned of the surrounding countries. Abdallatif found here many of the most eminent men of that age, part of whom were busied in the chimerical pursuits of the Hermetic art, and part in philological and speculative inquiries. He seems always to have entertained great contempt for the sort of chemistry then in vogue, but he entered with eagerness into speculative discussions; and he at this time composed a treatise upon the Divine essence and attributes, in consequence of some discussions with Alkendi, a philosopher of eminence, who was not, however, thought to be quite orthodox in his faith.

The active curiosity of Abdallatif was next directed to Egypt; and he accordingly proceeded to Acre, where its sultan, the great Saladin, was at the time encamped, in order to solicit his permission to visit that country. This monarch was a liberal protector of the learned, and fond of their conversation; but having been lately defeated by the Crusaders under Richard Cœur de Lion, he was too much occupied with the cares consequent upon this disaster, to admit Abdallatif to the expected honour of a personal interview. He was, however, received in a courteous manner by the Vizier Al Fadhel,

Abdallatif. whom he found in his tent writing and dictating at the same time to two secretaries; employments which he continued whilst he conversed with his visitor upon sundry points of grammar and philology. Having obtained the necessary credentials from this minister, he proceeded to Cairo; and the munificence which Saladin and his courtiers extended towards the learned, was strikingly exemplified in his reception and treatment in that city. He was provided with a house, with provisions, and money; and the Vizier seldom failed to recommend him anew, in those letters of business which he had occasion to write to the governor of the place.

Here Abdallatif enjoyed the long wished for opportunity of conversing with that *Eagle of the Doctors*, as he was called, the celebrated Maimonides, who had been for a considerable time settled in Egypt, and was physician to the sultan. Here, too, he was fortunate enough to meet with a sage, who weaned him of his admiration for the writings of Avicenna, by pointing out the superior value of the ancients. But the philosophers of Grand Cairo were not all of this stamp; for some of them were pretenders to the transmutation of metals, and one boasted that his art enabled him to fabricate a tent of the waters of the Nile. Having passed a considerable time in making various observations and collections in this interesting city, Abdallatif set out for Jerusalem, on learning that he would there see Saladin, who had at length concluded a truce with the Crusaders.

Saladin received him with every mark of respect for his talents, and bestowed upon him a pension. He was then busied in repairing the walls of the Holy City, himself, says Abdallatif, often carrying stones upon his shoulders, to animate the undertaking. But in spite of all his cares and projects, he daily conversed with the learned men whom his bounty had drawn around him. Abdallatif mentions, that when first introduced, he found him in the midst of a circle of this description; and he adds, that, upon all the various subjects which were discussed, the Sultan spoke with the most agreeable address, as well as ingenuity. From Jerusalem, Abdallatif returned to Damascus; and, after a considerable interval, a fresh opportunity having occurred of revisiting Egypt, he again proceeded to Cairo, where he taught medicine and philosophy for several years.

During this period, Egypt was visited with a terrible famine and pestilence, of which, and the horrors and crimes which ensued, he has given a most appalling description in the two last chapters of his Account of this country. Human nature was scarcely ever presented to observation under so hideous an aspect; the wretched Egyptians were driven, not only to feed upon the bodies of those who had fallen victims to want or disease, but to seize upon children, whom they killed and devoured; and Abdallatif asserts, that they thus came to acquire such a relish for those inhuman repasts, that they with difficulty refrained from them after the famine had subsided. It was likewise during his second stay in Egypt, that he witnessed an insane attempt to pull down the Pyramids; a project to which the reigning sultan (a son of Saladin's, who, after his death, succeeded to this part of his dominions) had been instigated by some of his favourites, and in which he persisted for eight months, without being able to make any sensible impression upon these indestructible monuments of the ancient world. Abdallatif.

About the year 1207, Abdallatif left Egypt for his former residence, Damascus; and here he for some time practised as a physician, and lectured upon medicine with great success. But his love of new scenes, and desire of extending his knowledge and fame, still urged him to travel; and he seems to have passed the rest of his life in Aleppo, and various parts of Armenia and Asia Minor, acquiring both wealth and glory by his abilities as a physician and an author. Having returned to his native city, purposing to present some of his works to the Caliph, and then to set out on a pilgrimage to Mecca, he was seized with illness soon after his arrival, and died there in the year 1231.

He was undoubtedly a person of great knowledge, and of an ardent, inquisitive, and penetrating mind. According to his Arabian biographer, to whom he was well known, he showed himself, in conversation, somewhat vain of his own attainments; and was accustomed to speak rather scornfully of most of his contemporaries. But it ought to be mentioned, to the credit of his understanding, that his derision seems partly to have flowed from his contempt of those chemical fooleries to which they were so much addicted, that, to use the words of Gibbon, "the reason and the fortune of thousands were evaporated in the crucibles of alchemy."

Of that long list of treatises on medicine, philosophy, and literature, which Osaiba has appended to the account of his life, one only has found its way into Europe; nor do any of the others appear to be known at this day in the East. The work here alluded to is his *Account of Egypt*, which was fortunately discovered, and brought to this country by our celebrated orientalist, Pocoke. The manuscript, which is a very old one, is still preserved in the Bodleian Library. Of this work, an elegant edition, with a Latin translation, notes, and a life of Abdallatif, was published in 1800, by Dr White, professor of Arabic in the University of Oxford. A French translation, with enlarged notes, was published at Paris in 1810, by M. Silvestre de Sacy; and to this, among other valuable illustrations, is appended a translation from an Arabic manuscript of the curious biographical memoir to which we have already alluded.

This account of Egypt consists of two books; the first of which, in six chapters, gives a general view of the country, of its plants, animals, antiquities, buildings, and modes of navigating on the Nile; and the second, in three chapters, treats at large of this river, and of that terrible famine already alluded to, which was occasioned by a failure in the usual annual increase of its waters. The book undoubtedly is, upon the whole, one of the most interesting productions which has come to us from the East; inasmuch as it presents us with a detailed and authentic view of the state of Egypt during the middle ages, and thus supplies a link which was wanting between the accounts of ancient and of modern times.

See *Abdollatiphi Historiæ Ægypti Compendium*,

Abdallatif || Aberdeenshire.

*Arabice et Latine*, 4to. 1800, Lond. *Relation de l'Egypte, par Abdallatif*, traduit par M. Silvestre de Sacy, de l'Institut de France, 4to. Paris, 1810.

Situation. ABERDEENSHIRE. The account given of this shire in the body of the work, is, in some particulars, incorrect, and in others, inadequate to its present state and circumstances. It is situate in the north-east of Scotland, between 56° 52′ and 57° 42′ of north latitude, and between 1° 49′, and 3° 48′ of longitude west from Greenwich. It is bounded by the German Ocean on the north and east; by the counties of Kincardine, Forfar, and Perth, on the south; and by those of Inverness, Moray, and Banff, on the west.

Extent. Its greatest length is 85, its greatest breadth 40 miles; and its bounding line about 280 miles, of which 60 are on the sea-coast. By a careful measurement of Arrowsmith's map, it is found to contain 1960 square miles, an area equal to 1,254,400 English, or 994,520 Scotch acres; of which somewhat more than one-third is under cultivation.

Divisions. It is usually described under five divisions. First *Marr*, which is a mountainous district, particularly Braemar, the Highland subdivision; few of its bounding mountains being less than 3000 feet, and several of them more than 4000 feet above the level of the sea. Red-deer are here found in great numbers, sometimes 300 in a flock; and moor game abounds in this as in all the more elevated parts of the county. Second, *Formartin*, of which the land on the sea coast is low and fertile; but hills and mosses are spread over the interior. Third, *Buchan*, the most extensive division next to Marr, which has been greatly improved of late by the cultivation of turnips and clover. Fourth, *Garioch*, a large and beautiful valley, naturally very fertile. Before the introduction of the modern husbandry, it was termed the granary of Aberdeen. And, fifth, *Strathbogie*, the greater part of which consists of hills, mosses, and moors. On a comprehensive review, it may be said, that, with the exception of the sea-coast of Buchan, which is flat, and of the south-west division, which is mountainous, Aberdeenshire is in general a hilly country; though it contains many large and fertile tracts, in a high state of cultivation. In extent, it is very nearly one-sixteenth part of Scotland.

Minerals. Aberdeenshire is not rich in mineral productions. No coal has been found in it, and limestone is by no means abundant. Slate quarries are wrought to a small extent on the hill of Foudland, in the Garioch division; manganese is found near Aberdeen; and black lead has been discovered in the neighbourhood of Huntly. The mountains of Braemar contain those precious stones called *Cairngorums* by the country people, who go thither in whole families to search for them during the summer season; and they are sold sometimes at high prices, chiefly to the London jewellers. But granite is the most abundant mineral, and has brought considerable sums into the county, besides supplying the inhabitants with excellent stones, for building and other purposes. As many stones are sometimes raised from an acre of land under preparation for tillage, as bring from L. 30 to L. 50, for paving the streets of London. The exportation of granite to the capital employs about 70 vessels of 7000 tons, and 400 men; and the value of all the stones exported yearly is stated at L. 40,000.

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Waters. The principal rivers are the Dee and the Don. The gross annual produce of the salmon-fisheries on these two rivers is estimated at nearly L. 35,000. The Ythan and Ugie within the county, and the Deveron and Bogie on its boundaries, are also considerable streams. Muscles are plentiful near the mouth of the Ythan; and pearl muscles have been sometimes discovered at its lower extremity. One of the jewels of the ancient crown of Scotland, a valuable pearl, is said to have been found here. There are also several lakes throughout the county well stored with pike, trout, eels, and other kinds of fish. The county is noted for its chalybeate springs at Peterhead and Frasersburgh.

Woods and Plantations. The district of Marr, containing almost half the county, abounds in natural woods and plantations, which are a source of wealth to their proprietors, and of profitable employment to the inhabitants. This country is so well adapted to the growth of trees, that it is only necessary to shut out the cattle by enclosures, and the birds and winds supply it with seeds that soon rise into vigorous plants. These woods consist chiefly of Scotch fir; and the timber, especially what grows in the forests of Braemar, has been found superior to any that Scotland has imported from the north of Europe. About a tenth part of the whole surface of the county is under wood; and the trees found in the peat mosses indicate the existence of still more extensive forests in former ages.

Ruins. Ruins of ancient edifices are seen in different parts of the county. In the Garioch district, the vitrified fort Dun-o-Deer, built on the summit of a beautiful conical hill, which springs about 300 feet from its base, is supposed to be 1000 years old; and is said to have been the residence of King Gregory the Great (as he is called by the old Scotish historians) who died in 892. The ruins of two buildings, supposed to have belonged to Malcolm Kenmore, who died in 1004, are still pointed out. One of them, situate at Castletown of Braemar, was his hunting-seat; the other stands in a small island in Loch Kanders, and must have been inaccessible, except when the lake was frozen. A wooden bridge, which connected it with the land, has been found in the lake. The castle of Kildrummy, which, in 1150, was the property of David, Earl of Huntingdon, must have been a princely edifice, covering nearly an acre of ground; and its venerable remains still shew the power and grandeur of the chieftains by whom it was inhabited. In the same district are some ancient subterraneous retreats, supposed to have been used by the Picts as places of refuge from an invading enemy.

Agriculture. The agriculture of Aberdeenshire has been considerably improved of late years; and wheat, as well as other grain, with potatoes, turnips, and clover, are now cultivated according to the best courses of modern husbandry. Farms, however, are still generally of a small size, compared with those of the south-eastern counties; and the buildings, though gradu-

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ally improving, are for the most part much less convenient and comfortable. Here, as in every other part of Scotland, a lease for nineteen years is the most common bond of connection between the landholder and farmer; but it would appear that the covenants of leases are still in a considerable degree dictated by feudal ideas.

Cattle.

In most parts of Aberdeenshire, cattle are a more important object to the tenantry than corn; the number is stated at 110,000; and the sales, to England and to the south of Scotland, amounting to about 12,000, are estimated to bring L. 150,000 annually. About two-thirds of the population depend entirely on agriculture; and oatmeal, prepared in different ways, is the principal food of the labouring classes.

Fisheries.

Besides the salmon-fisheries already noticed, the sea-fishing employs a number of hands. The Greenland whale-fishery has been carried on with great success, by ships fitted out from Aberdeen and Peterhead. The whole fisheries connected with the county yield from L. 80,000 to L. 100,000 annually.

Manufactures.

The staple manufacture, the knitting of stockings, has declined considerably for several years; and that of linen and thread has been deeply injured by the high price of flax during the late war. But these manufactures, together with those of woollen and cotton, are by no means inconsiderable. There are also establishments for making sail-cloth, inkle, paper, &c.; and, from the characteristic ingenuity and enterprize of the people, there is reason to expect that a few years of peace will greatly extend all these branches of industry.

Commerce.

This county has always possessed a share of our foreign trade, chiefly of that with the north of Europe; and the recent improvements on the harbour of Aberdeen must contribute essentially to the extension of its commerce. There were, in 1810, belonging to Aberdeen, Peterhead, and Newburgh, 207 vessels, carrying 23,390 tons, and employing 1473 men. In 1807 a canal was opened from the harbour of Aberdeen to the town of Inverury, a distance of 18¼ miles, the expence of which was about L. 44,000. The facilities which this canal affords for the conveyance of coal and lime have already proved highly beneficial to the agriculture of the county.

Rent.

The *valued rent* of the county is L. 235,665, 8s. 11d. Scots; and, according to the assessment to the property-tax for the year ending 5th April 1811, the *real rent*, which has been doubled within these 30 years, amounts, for the lands to L. 233,826, 19s. 10d. and for the houses to L. 65,557, 9s. 9d. Sterling.

Population.

The population of this county, as ascertained under the act of the 41st of the King, in 1800, was 123,082. The town and parish of Aberdeen at this time contained 17,597 inhabitants. By the returns made under the population act of 1811, the numbers were increased to 135,075 for the county, and 21,639 for the town and parish. In the returns made under these acts, the county was divided into eight districts, viz. Aberdeen, Alford, Deer or Buchan, Ellon, Garioch, Kincardine O'Neil, Strathbogie, and Turreff. The following tables will shew the results of the returns applicable to these districts at the two periods above mentioned. In this, as in the other maritime counties of the north, there is a considerable disproportion between the numbers of the sexes.

1800.

| DISTRICTS. | HOUSES. | | | OCCUPATIONS. | | | PERSONS. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Inhabited. | By how many families occupied. | Uninhabited. | *Persons* chiefly employed in Agriculture. | *Persons* chiefly employed in trade, manufactures, or Handicraft. | All other *persons* not comprised in the two preceding Classes. | Males. | Females. | Total of Persons. |
| Aberdeen, | 4,978 | 10,422 | 146 | 4,434 | 14,577 | 16,401 | 14,990 | 20,451 | 35,423 |
| Alford, | 1,939 | 1,942 | 49 | 5,460 | 847 | 2,141 | 3,993 | 4,455 | 8,448 |
| Deer, | 5,846 | 6,487 | 87 | 7,643 | 4,991 | 12,844 | 11,552 | 13,966 | 25,518 |
| Ellon, | 2,609 | 2,624 | 50 | 6,418 | 1,805 | 2,846 | 5,169 | 5,900 | 11,069 |
| Garioch, | 2,837 | 2,882 | 38 | 7,729 | 1,214 | 3,047 | 5,680 | 6,310 | 11,990 |
| Kincardine O'Neil, | 3,218 | 3,224 | 157 | 4,870 | 1,794 | 6,677 | 6,214 | 7,127 | 13,341 |
| Strathbogie, | 1,780 | 1,975 | 12 | 3,428 | 1,135 | 3,687 | 3,851 | 4,399 | 8,250 |
| Turreff, | 2,042 | 2,145 | 34 | 3,062 | 1,336 | 4,645 | 4,176 | 4,867 | 9,043 |
| | 25,249 | 31,701 | 573 | 43,044 | 27,699 | 52,288 | 55,625 | 67,457 | 123,082 |

1811.

| DISTRICTS. | HOUSES. | | | OCCUPATIONS. | | | PERSONS. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Inhabited. | By how many families occupied. | Uninhabited. | *Families* chiefly employed in Agriculture. | *Families* chiefly employed in trade, manufactures, or handicraft. | All other *families* not comprised in the two preceding classes. | Males. | Females. | Total of Persons. |
| Aberdeen, | 5,610 | 12,196 | 249 | 1,890 | 7,382 | 2,924 | 18,641 | 25,570 | 44,211 |
| Alford, | 2,012 | 2,019 | 19 | 1,220 | 392 | 407 | 4,251 | 4,800 | 9,051 |
| Deer, | 5,646 | 6,473 | 122 | 2,868 | 2,713 | 892 | 11,360 | 14,615 | 25,975 |
| Ellon, | 2,650 | 2,662 | 54 | 1,765 | 605 | 292 | 5,325 | 6,112 | 11,437 |
| Garioch, | 2,872 | 2,924 | 83 | 1,830 | 787 | 307 | 5,939 | 6,527 | 12,466 |
| Kincardine O'Neil, | 3,058 | 3,079 | 138 | 1,868 | 679 | 532 | 6,231 | 7,113 | 13,344 |
| Strathbogie, | 1,975 | 2,089 | 36 | 978 | 880 | 231 | 4,007 | 4,821 | 8,828 |
| Turreff, | 2,177 | 2,276 | 44 | 1,218 | 848 | 210 | 4,405 | 5,358 | 9,763 |
| | 26,000 | 33,718 | 746 | 13,637 | 14,286 | 5,795 | 60,159 | 74,916 | 135,075 |

(A.)

ABERRATION, (Spherical,) see CATOPTRICS and DIOPTRICS in this Supplement.

Abortion.

ABORTION. The reader will find some historical remarks, in the body of the work, in regard to the practice of procuring abortion, with a view to the destruction of the fœtus; and we resume the subject in this place, partly to notice some recent discussions of a similar kind, and partly to state in what manner the offence is viewed in the laws of our own and the neighbouring country. It has sometimes been doubted, whether this unnatural practice was ranked as a crime in the laws of Greece and Rome; and we find, from the last report of the proceedings of the literary class of the French Institute, that the question has been revived, and elaborately discussed by some members of that learned body. The subject, it seems, had been incidentally alluded to, in a discourse of Count Gregoire's upon the influence of Christianity on the condition of the female sex, read in the early part of last year. (1814.) This produced two dissertations, one by M. Clavier, and the other by M. Boissonade; the first maintaining the impunity of the practice among the ancients, the last, that it was on the contrary viewed as a penal offence.

We find, says M. Clavier, that in one of Plato's dialogues, (*Theæt.*) Socrates is made to speak of artificial abortion, as a practice not only common, but allowable; and Plato himself authorizes it in his *Republic*, (Lib. v.) Aristotle (*Polit.* Lib. vii. c. 17,) gives it as his opinion that no child ought to be suffered to come into the world, the mother being above forty, or the father above fifty-five years of age. Lysias maintained, in one of his pleadings quoted by Harpocration, that forced abortion could not be considered homicide, because a child *in utero* was not an animal, or separate existence. M. Clavier admits, that, in a treatise ascribed to Galen, *(An animal sit quod in utero est?)* there is mention made of enactments by Solon and Lycurgus against this crime; but he maintains that this is a spurious production, and that at any rate, his testimony cannot be opposed to that of so many writers, who lived long before his age. Among the Romans, Ovid (*Amor.* Lib. ii.), Juvenal (*Sat.* vi. v. 594), and Seneca (*Consol. ad. Helv.* 16.), though they lament in strong terms the frequency of this enormity, yet they never allude to any laws by which it might be suppressed. Various other writers, it is said, preserve the same silence on this point, whilst joining in general reprobation of the crime.

On the other hand, M. Boissonade appeals not only to the authority of Galen, but of Cicero, *(Pro Cluentio,)* as placing it beyond a doubt, that, so far from being allowed to pass with impunity, the offence in question was sometimes punished with death. With regard to the authority of Lysias, he states, that the pleading referred to is quoted by Harpocration himself as of dubious authenticity; and, as to Plato and Aristotle, he observes, that their speculative reasonings, in matters of legislation, ought not to be confounded with the actual state of the laws. And he adds, that Stobæus (*Serm.* 73.) has preserved a passage from Musonius, in which that philosopher expressly states, that the ancient lawgivers inflicted punishments on females who caused themselves to abort.

It seems indeed difficult to believe, that the practice in question should have been allowed to prevail without being denounced as criminal by the lawgivers of Greece and Rome; but it is not so clear that there was any law which punished it with death. Those readers who have any curiosity to enter more deeply into the inquiry, will be enabled to do so, by consulting the various authorities to which M. Clavier and M. Boissonade have appealed, in support of their respective views of the question. The notorious frequency of the practice forms an odious feature in the manners of ancient times. Seneca makes it a ground of distinction for Helvia, that she had never, like others of her countrywomen, destroyed the child in her womb, in order to preserve her shape.

By the law of England till very lately, the only party held to be guilty of murder in forcing abortion was the woman, when she was proved to have taken means to destroy a child *quick* in the womb, and actually to have thereby destroyed it. But in 1803, an act was passed, inflicting the punishment of death upon *all* concerned in *administering* any noxious sub-

stance with the *intent* to procure the miscarriage of any woman *quick* with child. The procuring or attempting it before the child has quickened, is punishable only with imprisonment or transportation. This law is evidently grounded upon a false hypothesis—that the fœtus is not quick or alive till its motion in the womb becomes perceptible to the mother; and, what is of more importance, it makes no provision against the attempt to procure abortion by *manual* application. The reader will find a curious illustration of this defect, in a trial which occurred at the assizes held at Bury St Edmunds, in 1808. See *Trial of William Pizzy*, &c. Ipswich, 1808.

The case of John Fenton, tried at Perth in 1763, was the first instance of a criminal prosecution for this offence in Scotland; and here the public prosecutor restricted the libel to an arbitrary punishment. Our writers indeed agree, that, by the law of Scotland, the forcing of abortion is not homicide, whether the child be quick or not, except where the mother is killed in the process. Imprisonment or transportation may, and is all that can, in any case, be inflicted; and in a recent instance, a surgeon and midwife were, upon conviction for the offence, sent to Botany Bay for fourteen years.

ABOULFEDA, or Abulfeda, the most celebrated of the Arabian writers on history and geography. Among his contemporaries he was also distinguished both as a ruler and a warrior. His descent was in a direct line from Ayoub, father to Saladin, and from whom the house of that conqueror received the appellation of Ayoubites. Omar, the grandson of Ayoub, was one of Saladin's most distinguished generals, and enjoyed the privilege, which he transmitted to his posterity, of being placed always on the right of the army. In reward of his services, he was created Prince of Hamah, the ancient Apamea, which, with some territories adjoining, became hereditary in his family. They were transmitted, in the course of succession, to Mahommed Mahmoud, and to Mahommed, the uncle of Aboulfeda. Although none of these princes equalled the military glory of Omar, they were yet distinguished, both in arms and letters. Continually engaged in military expeditions, their court was at the same time open to learned men. It is mentioned, among the proofs of their zeal for science, that Mahmoud caused to be constructed at Hamah, a gilded sphere of great magnitude, on which all the stars then known were represented.

Aboulfeda was son to Aly, the brother of Mahommed. He was born at Damascus in the year 672 of the Hegira, (1273 A. D.) His early years were spent in the study of the Koran and of the sciences. By the age of twelve, however, he was summoned to the field, and was present at the attack of Marcab, a castle belonging to the knights of St John. Syria was then shaken by continual war, and thus scarcely a year elapsed, in which the young prince was not called out upon some military expedition. He successively assisted at the sieges of Tripoli, Acre, and Roum. In 1298. Prince Mahmoud, his cousin, who held the sovereignty, died, and left Aboulfeda heir. The succession, however, being violently disputed by his two brothers, the court, in consequence of their dissensions, took occasion to supersede all the three; and the Ayoubites lost the principality which they had enjoyed for more than a century. Aboulfeda, however, by his valour and other eminent qualities, soon recommended himself to the favour of the Sultan Melik-el-Nassir. He was present, and took an active part in the victory gained at Alkoroum in 1302, and in the still more signal one near Damascus in 1303, by which Syria was for the time delivered from the incursions of the Tartars. But peace was soon followed by internal dissensions. The throne of Egypt was disputed with Melik-el-Nassir by Bibars, who at first succeeded in obtaining possession of it. His rival, however, being supported by the great men of Syria, among whom Aboulfeda took a conspicuous part, finally triumphed. Aboulfeda, who had always stood well with Melik-el-Nassir, rose then into peculiar favour. The Sultan took the first opportunity of establishing him in his patrimonial dignity of Prince of Hamah. Honours continued to shower upon him; he was invested with the distinctive marks of sovereignty, which consisted in the power of coining money, and in having prayers said in his name. The epithet *Melik Mowayyad*, victorious Prince, was conferred upon him, and it is stated by an Arabian author, that the sultan, in writing, addressed him by the appellation of brother.

The rest of Aboulfeda's life was spent in splendour and tranquillity, devoted to the government of his territory, and to the pursuits of science. Besides cultivating, he patronized literature, and his court became the rendezvous of all the learned men of the east. He conversed with them familiarly, bestowed upon them honours and pensions, and being himself superior to all in learning, felt no jealousy of their acquirements. During the same period, he composed the works which have transmitted his name to posterity. In this enviable manner he spent the period of twenty years, when an illness, of which the particulars are not related, carried him off on the 26th October 1331. He was succeeded by his son Melik-el-Afdhal, of whom little is recorded, and who was the last Prince of Hamah.

The two works by which Aboulfeda is known in Europe, are his *Geography*, and his *History*. The former ranks at least equal to any composed upon that subject by the Arabian writers. It partakes indeed of their general defects; for, although he seems to have paid more attention to the latitudes and longitudes than the rest of his countrymen, yet the imperfect application of astronomy, and the obscurity of his notation, have much diminished the value of this part of his labours. It is chiefly in the historical and descriptive parts, that he can now be regarded as an authority. Here too his knowledge, as he himself candidly confesses, is chiefly confined to the circle of Moslem dominion; but within those limits, the information conveyed by him is undoubtedly valuable.

His *History* possesses still higher claims to distinction. His method, as was usual with his countrymen, is entirely that of annals, and is in many parts too much abridged; but the work contains much valuable information with regard to the Saracen, and even to the Greek empires. It is divided into five parts, beginning at the creation of the world, and ending with the year 1328.

There are copies of his *Geography* in manuscript, in the national library of France, in that of the university of Leyden, and in the Bodleian. It has hitherto been published only in fragments, of which the following are the principal. *Chorasmia et Mawaralnahra* a Joan. Gravio, Londini; reprinted along with *Arabia*, in Hudson's *Geographi Græci Minores*, Oxford 1698-1712.—*Tabula Syri*, Arab. et Lat. by Koehler and Reiske, 4to. Leipsic, 1766.—*Descriptio Ægypti*, Arab. et Lat. Michaelis, Gotting. 8vo, 1776.—*Africa, Arab. cum notis J. G. Eickhorn*, Gotting. 1791.—*Arabia, cum commentario*, Chr. Rommel, Gotting. 4to, 1801. Complete editions were undertaken by Bishop Hyde, by D'Arvieux, in conjunction with Thevenot, and by Gagnier, the translator of the life of Mahomet; but different circumstances prevented their execution. We are happy to understand, that M. Langles, whose name stands so high, both as an orientalist and a geographer, has undertaken a complete edition of all the Arabian, Persian, and Turkish writers upon that subject, in the national library at Paris. In the course of this undertaking, he has already translated a large portion of the work of Aboulfeda.

The *History* of Aboulfeda is also found in manuscript in the French, Bodleian, and Escurial libraries. A great part of the copy preserved in the first is believed to be autograph. This work also has been published only in fragments. *Life of Mahomet*, Arab. et Lat. Gagnier, fol. Oxoniæ 1723.—*Annales Moslemici*, Lat. Reiske, Lipsiæ, 1754.—*Annales Moslemici*, sumptibus P. F. Suhmii, 5 tom. 4to. Hafniæ, 1789-94. Suhm was historiographer and chamberlain to the King of Denmark. The edition is excellent, and enriched with notes by Reiske.

See *Notice Historique sur Abulfeda et ses Ouvrages*, Par Am. Jourdain. Malte Brun. *Annales des Voyages*, Tom. XVIII. (B.)

ABSENTEE, a term applicable to any person who is absent from his station, employment, or country; but which has been more commonly used with regard to Irishmen who possess estates in their native country, and reside in England. This class of proprietors has been always viewed with a considerable degree of jealousy and dislike by their countrymen; they have been held up to public reprobation, as men who drained their country of its wealth, without contributing any thing either to its government or prosperity; and hence it has been frequently proposed to subject their Irish profits and properties to a separate penal tax. Dr Smith has incidentally adverted to this subject in the following terms: "Those who live in another country contribute nothing, by their consumption, towards the support of the government of that country, in which is situate the source of their revenue. If, in this latter country, there should be no land-tax, nor any considerable duty upon the transference either of moveable or immoveable property, as is the case in Ireland, such absentees may derive a great revenue from the protection of a government to the support of which they do not contribute a shilling. This inequality is likely to be greatest in a country of which the government is, in some respects, subordinate, and dependent upon that of some other. The people who possess the most extensive property in the dependent, will, in this case, generally choose to live in the governing country. Ireland is precisely in this situation; and we cannot, therefore, wonder that the proposal of a tax upon absentees should be so very popular in that country. It might, however, be a little difficult to ascertain either what sort, or what degree of absence could subject a man to be taxed as an absentee, or at what precise time the tax should either begin or end." (*Wealth of Nations*, B. v. c. 2.)

Under such views an act was passed in 1715, imposing a tax of four shillings in the pound upon the profits of employments, fees, or pensions, derived from Ireland, in all cases where the persons receiving them should not reside six months in the year within the kingdom. This tax was continued by several renewed acts till 1753, when it was allowed to drop; it having been found that the dispensing power reserved to the Crown had been so frequently exercised, as to render the tax in a great degree nugatory. (*Wakefield's Ireland*, Vol. II. p. 250.) The more general measure of a tax of two shillings in the pound upon all rents and profits, to be paid by all who should not reside within the country for the above period, yearly, was brought forward, much to the satisfaction of the community at large, by the celebrated orator Mr Flood, in 1773. This proposal at first received the support of the Earl of Harcourt, then Lord Lieutenant; but, after much debate, it was lost, by a division of 122 against 102. It has been said, that the British ministry, moved by some strong private remonstrances against the tax, had sent orders to Lord Harcourt to withdraw his support, when the question was nearly advanced to a favourable decision; but we are informed by Mr Hardy, in his valuable life of Lord Charlemont, that the main cause of its failure was, the apprehension that a general land-tax would be the consequence of this partial one upon absentees. "If the powerful interest of this body had hitherto been able to secure Ireland against such a tax, the same interest, it was thought, would be sufficient, and would be exerted to introduce it; in order that the other inheritors of landed property should, as such, be made to pay a tax as well as themselves." In 1783, the question was again brought before the Irish House of Commons by Mr Molyneux, and lost by a division of 184 against 22. (*Plowden's Ireland*, Vol. II. p. 64.)

It is not now necessary to investigate at any length the policy of a measure which had received its deathblow, even before the union of the two kingdoms had rendered it altogether impracticable. But it may be observed, that Dr Smith does not seem to have taken a large view of the subject, in pointing out, as the only objections to the tax, "the difficulty of ascertaining what sort and what degree of absence should subject a man to pay it, or at what precise time it should begin or end." The great objection lay in the odiousness and the impolicy of such a restraint upon the intercourse of two countries so closely connected in their interests, and united under the same federal head. "What," says Mr Burke, in his admirable letter upon this subject to Sir Charles Bingham, "is taxing the resort to and residence in any place, but declaring that your connection with that place is a grievance? Is not such a tax a virtual declaration that England is a foreign country, and a

renunciation of that principle of *common naturalization* which runs through this whole empire?—I know very well," he further observes, "that a great proportion of the money of every subordinate country will flow towards the metropolis. This is unavoidable; other inconveniences too will result to particular parts; and why? because they are particular parts, each a member of a greater, and not an whole within itself. But these members are to consider whether these inconveniences are not fully balanced, perhaps more than balanced, by the united strength of a great and compact body." (Works, Vol. IX.)

But although it be true that the privilege of unfettered intercourse and discretionary residence is essential to the harmonious and beneficial union of two such countries, it does not therefore follow, that Ireland has no cause to lament the constant absence of so large a proportion of her great landed proprietors. There are many circumstances connected with the peculiar habits and condition of her people, which strongly call for their occasional presence and example. She suffers from this dereliction, not so much because large sums are thereby annually drawn from her to be spent in England, as because her yet poor and rude tenantry are thereby left to the government of persons who have comparatively but little interest in their prosperity, or influence upon their improvement. The reader will find ample details in regard to the condition and management of absentee property in Mr Wakefield's late *Account of Ireland*. Its amount was, in a report of a committee of the House of Commons, ordered to be printed in May 1804, estimated at two millions *per annum*.

ABULFAZEL, who is called by Sir William Jones, "a learned and elegant," and by others, "the most elegant" writer that the East has produced, was Vizier and Historiographer to the Great Mogul, Akber. We have not been able to discover the year of his birth, but his death took place in 1604, when he was assassinated on his return from a mission to the Decan. According to some writers, this foul act was perpetrated at the instigation of the heir apparent to the throne, who had become jealous of the minister's influence with the emperor. Akber greatly lamented the loss of a man who was not only an able minister of state, but of such talents as a writer, as to make it a common saying in the East, "that the neighbouring monarchs stood more in awe of his pen than of the sword of his master." He wrote, by the emperor's command, a history of his reign, which came down to the forty-seventh year, in which he was assassinated. In connection with this, he also compiled a volume, intended to exhibit a geographical and statistical view of the empire, and of the revenue, household, and expences of the sovereign. It likewise embraces an account of the religion of the Hindoos, of their sacred books, and their several sects in religion and philosophy. This work, which is fraught with much curious and valuable information, is known under the name of the *Ayeen Akbery*. It has been translated into English with great accuracy by Mr Francis Gladwin. The translation was undertaken and published at Calcutta, under the intelligent patronage of Mr Hastings. "Such a work," he said, in a minute of council, "could not but prove peculiarly useful; as it comprehends the original constitution of the Mogul Empire, described under the immediate inspection of its founder, and will serve to assist the judgment of the Court of Directors on many points of importance to the first interests of the company."—The Calcutta edition, published in 1783-6, in three volumes quarto, is a splendid book, and the most valuable in every respect, as the London reprints are by no means accurate.



ABU-TEMAN, an Arabian poet, of whom, though but little can be said, it would be improper altogether to omit, because he was held to be the Prince of Arabian poets, during the best periods of Arabian literature. He was born about the year 787; and, happily for him, under sovereigns whose love and patronage of literature, made poetical eminence an unfailing road to wealth and honour. Part of his early life was passed in Egypt, in the servile capacity of administering drink to those who frequented a mosque. It is also said, that he was for sometime employed in the trade of a weaver at Damascus. But his talents for poetry soon lifted him from this humble sphere, and removed him to Bagdad, where the Caliphs loaded him with presents, and treated him with the greatest respect. If we are to believe the Arabian historians, a single poem sometimes procured for him many thousand pieces of gold. So highly was he esteemed by his countrymen, that it was said "no one could ever die, whose name had been praised in the verses of Abu-Teman!" His own life was very short, for he died in his fortieth year; "the ardour of his mind," says one of his contemporaries, "having wasted his body, as the blade of an Indian scymeter destroys its scabbard." Besides being a great original poet, he was the compiler of three collections of select pieces of the poetry of the East; the most esteemed of which collections is that called the *Hamasa*. Sir William Jones speaks of it as a very valuable compilation. Many of the elegant specimens of Arabian poetry contained in Professor Carlyle's well known work, were translated from pieces contained in this miscellany. A large portion of it, with a Latin version, was annexed by Schultens to his edition of Erpenius's *Arabic Grammar* published at Leyden in 1748; and there are also many extracts from it in the collection entitled *Anthologia Arabica*, published at Jena in 1774.

ABYSSINIA. The account of this remote and little known country already given in the body of the work, is almost wholly derived from Mr Bruce's *Travels*. Much new and corrective information has been laid before the public, since the first appearance of that celebrated work; and, in communicating the results, we shall enlarge the scope of this supplementary article, so as not only to exhibit a view of the present state of the country, but of the progress of European discovery in regard to it, from the earliest existing accounts until the period of Mr Salt's last visit. When we come, in the course of this historical survey, to the epoch of Mr Bruce's adventurous journey, we shall avail ourselves of the occasion, to examine, at some length, the various opinions which have of late years been advanced, in regard to the value and the veracity of his details.

Abyssinia.

Account of travellers in Abyssinia.

I. About the year 330, an ecclesiastic named Frumentius, who had been travelling with his relation, Meropius, a Tyrean philosopher, and who, at an island in the Red Sea, had become acquainted with some Abyssinians, represented to Athanasius, the patriarch of Alexandria, the wish of these people to have Christianity introduced into their country. Frumentius was accordingly consecrated Bishop of Axum by the patriarch, and appears to have made many converts among the Abyssinians. But as Constantine the Roman Emperor had embraced Arianism, and was at variance with the Patriarch of Alexandria, he was desirous to recal Frumentius, either that he might appoint an Arian bishop, or that Frumentius might be re-consecrated by one of that persuasion. With this view he wrote a letter to the monarch of Abyssinia. By whom this letter was conveyed, is not certain, though it is probable that it was by a person named Theophilus, who travelled into that country about A. D. 333. The only notice which remains of the journey of Theophilus, is given by Philostorgius (*Hist. Eccles.*), and it is very meagre. Theophilus found the descendants of some Syrians in Abyssinia, sprung, he supposes, from a Syrian colony, planted there in the time of Alexander the Great.

Theophilus, A. D. 333.

Nonnosus, A. D. 533.

In the year 533, the conquests of the Abyssinians in Arabia, and the warm professions of friendship which they held out to the Roman empire, induced Justinian to send an embassy into that remote country, with the hope of persuading its sovereign to employ his forces then in Arabia against the Persian monarch. At this period, the Abyssinians were acquainted with the arts of navigation, and had recently imbibed the spirit of trade, and acquired the sea port of Adule, from which they penetrated along the African coast, as far as the equator, in search of gold, emeralds, and aromatics. For this important commission, Justinian selected Nonnosus, descended from a family of ambassadors. He took the route of the Nile, from which he crossed to the Red Sea, and landed at the port of Adule. Though the distance of this place from Axum, at that period the residence of the sovereigns of Abyssinia, is only fifty leagues, yet the winding passes of the mountains, which lie between them, detained Nonnosus fifteen days. He was received with great pomp and favour by the Abyssinian monarch, Anda, or Ameda; but we are not very distinctly informed as to the fate of his mission. Of his original narrative, some extracts only are preserved in the *Bibliotheca* of Photius, and in the *Chronographia* of John Malala. From these, among other particulars, we learn that Nonnosus saw, in his passage through the forests, which intervene between Adule and Axum, an immense number of wild elephants; and that the Abyssinian monarch gave audience in an open field, seated on a lofty chariot drawn by four elephants, superbly caparisoned, and surrounded by his nobles and musicians. In his hand he held two javelins, and a light shield; his clothing was a linen garment and fillet; and though thus imperfectly covered, he displayed a profusion of gold chains, collars, and bracelets, adorned with pearls and precious stones. Nonnosus represents Axum as large and populous. In detailing his passage over the mountains of Taranta, he remarks the great contrast of the seasons on different sides of it; from Ave to the coast, it was summer and harvest time; whereas from Ave to Axum, and the rest of Abyssinia, it was winter. The truth of this observation is amply confirmed by Mr Salt.



Abyssinia.

Cosmas.

About the same period, Cosmas, surnamed *Indicopleustes* or the Indian Navigator, visited Adule. It was the design of this author, in publishing his work, entitled *Topographia Christiana*, to confute the heretical opinion that the earth is a globe, and offer proofs that it was a flat oblong, as represented in the Scriptures. His voyage was performed A. D. 522, and his book published at Alexandria, A. D. 547. Photius, to whom we are indebted for many curious extracts from works now lost, gives some interesting passages from it; and the complete work was published by Montfauçon, at Paris, in 1707, in the *Nova Collectio Patrum*, Tom. II. The most valuable part of it has been published in French and Greek, by Melchisidec Thevenot, in his *Relations de Divers Voyages Curieux, non encore publiées, ou traduites.* Paris, 1682. To this author we are indebted for the Adulic Inscriptions. It appears that Elesbaan, king of the Axumites, had ordered the governor of Adule to send him a copy of these inscriptions; and the governor employed Cosmas, who happened to be there at that time, and one Menas, a merchant, for that purpose. Till Mr Salt examined these inscriptions, during his first journey, they had always been regarded as forming only one; though in this view, their meaning was not very clear, and they were at variance with authenticated history; but he satisfactorily proved, that instead of being a single inscription, referring exclusively to Ptolemy Evergetes, there were two distinct inscriptions, one of which refers to Ptolemy, and the other to the affairs of Abyssinia. The former inscription, among other things, mentions that Ptolemy and his father were the first that brought elephants from the Troglodytes and Ethiopia.

Besides the interesting information which Cosmas affords respecting the port and inscription of Adule, he particularly describes the trade of the Axumites along the African coast of Barbaria or Zingi, and as far as Trapobane, Ceylon; and mentions, that every other year the King of Axum sent several persons of distinction to traffic with the natives of Agow for gold, which they bartered for cattle, salt and iron. The journey commonly occupied six months. He represents the fountains of the Nile as in the vicinity of Agow, which sufficiently points it out as the country of the Agows mentioned by Peter Paez, who travelled in Abyssinia in the beginning of the seventeenth century.

Respecting Abyssinia, the notices of travellers are few, and very meagre, from the time of Cosmas and Nonnosus, to the conclusion of the fifteenth century. We find it mentioned by Marco Polo, and by Ibn El Wardi, an Arabian author; and some slight notices, particularly of the religious missions into that country, till the year 1500, are supplied by Renaudot, from the Coptic writers, in his *Historia Patriarcharum Alexandrinorum*. Paris, 1713.

At the close of the fifteenth century, the Portuguese

Abyssinia.

Portuguese Missions; their origin.

missions into Abyssinia commenced: they originated in rather a singular circumstance. John II. King of Portugal, was extremely anxious to discover the residence of Prester John, who had long been represented in Europe as a Christian sovereign of great power, ruling somewhere in the centre of Asia. For this purpose, John sent Peter Covilham, and Alphonso or Michael de Payva, into Asia: the latter soon died, but the former, during his abode on the western coasts of the Red Sea, hearing much of the Abyssinian emperor, and of his being a Christian, concluded that he had found the object of his search. He immediately conveyed this information to his own court, and proceeded himself to Shoa, then the residence of the *Negush*, or monarch of Abyssinia. He was received and treated with great kindness and respect; but, according to the usual policy of the Abyssinian court at that period, he was not permitted to leave the country. An account of his residence is given by Damiana Goez, in his *Legatio Magni Indorum Presb. Joan. ad Emanuel Lusitaniæ.* Antwerp, 1552. King Emanuel, who was desirous of maintaining an intercourse with the sovereign of Abyssinia, (not less from commercial and political than religious motives,) sent an embassy into that country, in the year 1520. At the head of this embassy he placed the famous Edward Galvan, who had been secretary of state, and ambassador in France, Germany, and Rome. The selection of such a man points out the importance which Emanuel attached to this mission. But unfortunately, Galvan, being extremely old, was unequal to the fatigues of so long and dangerous a journey, and died soon after the embassy entered the Red Sea. In his stead, Rodriguez de Lima was appointed, and Francisco Alvarez, who had been chaplain to Galvan, was continued in the same office by Rodriguez. Their journey from the coast of the Red Sea was long and troublesome, on account of the heat of the climate, and the badness of the roads; but they arrived at the Abyssinian court on the 12th of April 1520, where they were received with much splendour and courtesy by the Emperor David. They were detained in Abyssinia six years from various causes; and on their departure, the emperor requested Rodriguez to leave behind him his physician, John Bermudez, and a painter of his retinue, with which request the ambassador complied. Alvarez wrote a minute account of Abyssinia, of which there are several editions;—that published by himself at Lisbon in 1540; a Spanish translation from the Portuguese, published at Antwerp in 1557; an Italian translation from the Portuguese manuscript, published by Ramusio in his *Collection of Voyages*, lib. i., (which differs materially from the Lisbon edition;) a French translation in 1558; and an English translation, in Purchas's *Collection of Voyages*. The value and accuracy of this author's statements have been differently appreciated; but it seems probable that several fabrications were published in his name; for Damiana Goez asserts, that he had seen a journal written by Alvarez, very different from most of the published works.* In some respects, the description which he gives of Abyssinia is extremely valuable. No European traveller, since his time, has visited Angot, Amhara, and Shoa; the first a region occupied by the Pagan Galla, and bordering with some barbarous tribes near the Red Sea. This traveller visited Axum a short time before it was almost totally destroyed by the Turkish invasion, and he describes it as a large and beautiful place. According to him, none of the cities of Abyssinia contained more than fifteen hundred houses; a statement, with which the assertion of Bruce, that Gondar, when he was there, contained ten thousand families, can hardly be reconciled.

Covilham, 1499.

Rodriguez de Lima, 1520. Alvarez.

Bermudez, 1538.

In the year 1538, Bermudez was sent back to Portugal, as ambassador from the Abyssinian monarch; and after a short abode at Lisbon, he was ordered to return, by the way of Goa, and take from that place some troops, to reinforce the Abyssinian, who, at this period, had been compelled to take shelter from the Moors in the mountainous part of his kingdom. The reinforcement was landed at Massowa, and, after a difficult journey, through the mountainous passes and defiles, they joined the Emperor. Bermudez published an account of his journey at Lisbon in 1565. There are also editions of it published at the same place in 1569 and 1615, which are very scarce. It was translated into English by Purchas, (*Pilgrims*, l. vii. c. 7. p. 1149,) and from thence into French by La Croze, (*Christianisme d'Ethiopie*, p. 92—265.) But the greater part of his work relates to the victories, defeat, and death of the Portuguese general, Christopher de Gama; and is principally valuable from the description which he gives of some, otherwise little known, parts of the country, which he visited in the course of the war.

1556.

In the year 1556, Ignatius Loyola, at the urgent request of an Abyssinian priest called Peter, who had visited Rome, projected a new mission into Abyssinia, and by his influence with the King of Portugal, persuaded him to send an ambassador and a patriarch along with the missionaries. They went first to Goa, where they learned that an entrance into Abyssinia, by the Red Sea, would be extremely difficult and dangerous, if not quite impracticable, as the Turks carefully guarded the sea-coasts with their ships. In consequence of this intelligence, it was resolved that the ambassador and the patriarch should not attempt the journey; and of the missionaries only one arrived in Abyssinia. An account of this mission was published in 1615;† it contains a great deal of curious information, but ought to be read, like all the other accounts of the Jesuit missionaries, with great caution.

Mendoza, 1589.

From this period, till the close of the sixteenth century, Abyssinia was extremely difficult of access, in consequence of the Turks having exclusive possession of the sea-coast. At length, in 1589, Philip II. of Spain, anxious to renew the alliance between the two courts, sent a letter to the Abyssinian monarch by an Italian bishop, John Baptista, and a person of the name of Lewis de Mendoza, who was then settled at Diu, and

* The translation of Ramusio was made from a manuscript supplied by Goez.

† De Æthiopiæ Patriarchis, J. N. Barreto et Andrea Oviedo, P. N. Godigno. Lugduni, 1615.

was well acquainted with the commerce of the Red Sea. The bishop died during his journey, but Mendoza penetrated into Abyssinia, delivered his letter, and carried back one from the Emperor to Philip. In consequence of his success, Mendoza was sent on a second mission, and sailed from Goa in February 1589, accompanied

Peter Paez, 1589.

by Antonio de Montserrato, a Catalonian, and Peter Paez, a Spaniard. In their voyage they were shipwrecked, and taken prisoners. This circumstance proved of great advantage to Paez, who, being a man of considerable talents, and of great activity of mind, as well as zeal, spent the seven years of his captivity in making himself a perfect master of the Arabian language. In consequence of the intelligence of their misfortune reaching Goa, two other missionaries were dispatched for Abyssinia; Abraham de Georgiis, a man of great learning and courage, and a thorough master of all the Eastern languages, and Belchior de Sylva, by birth an Indian: only the latter, however, arrived in Abyssinia, the former having been taken and beheaded by the Mahommedans. In the mean time, Peter Paez having been ransomed, found means to penetrate into Abyssinia, where he soon gained an ascendancy over the mind of the Emperor. He is the first European who visited what the Abyssinians deem the sources of the Nile. He died in that country, in the year 1622; and his manuscript, detailing the affairs of Abyssinia from the year 1556 to his death, was transmitted to Rome, where it is said to be still preserved. The only extract which has been printed from it relates to his journey to the sources of the Nile, and is given by Kircher in his *Œdipus Egyptiacus*.

D'Almeyda, 1623.

Paez was succeeded, in 1623, by Father Emanuel D'Almeyda, who travelled from Massowa, by Adejada, across the plain of Serawe, and partly along the course of the Mareb, till he arrived at the monastery of Fremona, the usual residence of the missionaries. He was succeeded by another of the society of Jesuits called Antonio de Angelis, who was famous for his skill in the Amharic language. In

Mendez, 1624.

1624, Alphonso Mendez was sent patriarch into Abyssinia. He arrived at Fremona on the 21st of June in that year; but, on account of the dangerous travelling through Tigrè at that season, he was obliged to stay there till the October following, when he went to the residence of the Emperor, by whom he was received with great pomp. His behaviour, however, was not such as to render him long a favourite; and he was ordered to retire to Fremona. Scarcely had he arrived here, before he received a fresh order to leave the kingdom; and, not immediately complying, he was conducted to Massowa. He wrote the history of Abyssinia in Latin, a French translation of which was printed at Lisle in 1633.* During the residence of

Peter Heyling.

Mendez in this kingdom, Peter Heyling of Lubeck, a Lutheran, well versed in the Arabic, ingratiated himself into the favour of the *Abuna*, or metropolitan bishop of Abyssinia at Alexandria, and visited that country along with him; and he continued for several years, being highly esteemed by the court and the clergy, both on account of his skill and success in medicine, and his knowledge of the oriental languages, and of polemic divinity. Respecting the cause and period of his return, there is some obscurity. Mendez asserts that he was ordered to leave the kingdom; whereas Ludolphus asserts that the Emperor was very unwilling to part with him. He did not live to revisit Europe, having been put to death on his return, either by the Arabs or by the Bashaw of Suakem. An account of his life, and the few particulars which he transmitted to his friends respecting Abyssinia, were published, in German, in the year 1724, along with an epitome, in the same language, of Geddes's *Ecclesiastical History of Ethiopia.* From the character and attainments of Heyling, in connection with the opportunities of observation and information which he enjoyed, there is no doubt that, had he lived to return to Europe, he would have added considerably to the stock of knowledge at that time possessed regarding this country.

Lobo.

In the suite of Alphonso Mendez was Father Lobo, who, during the greatest part of the nine years that he resided in Abyssinia, was rector of the college of Fremona. His description of that country, and history of his travels, though simple and succinct, is much superior, in clearness and accuracy, to the relations of any of the travellers who had preceded him. Lobo resided for some time in the province of Damot, near the sources of the Nile. It has been supposed, though, we imagine, erroneously, that *A short Relation of the River Nile, of its Source, and Current, by an Eye-witness*, which was first published in 1668, and afterwards republished by Dr Rotheram, in 1791, was procured at Lisbon from Lobo himself. This account of the sources of the Nile differs in some respects from the account given in Le Grand's translation of Lobo. His work was originally published in Portuguese, but it is much better known in the French translation of Le Grand, and in the English translation by Dr Johnson.

In 1660, Father Tellez, at the request of the society of Jesuits, published his General History of Abyssinia under the following title: *Historia General de Ethiopia, alta o' Preste Joan*, &c. Coimbra, fol. 1660.† In compiling this work, he had the advantage of consulting all the relations which the missionaries had drawn up, as well as the annual letters which they had sent to the college of Jesuits at Lisbon; and, as is noticed in the title-page, the relation of Emanuel d'Almeyda is here abridged.

The Portuguese having lost their credit and influence in Abyssinia, by the haughty behaviour of Mendez, the French resolved to use their endeavours to establish themselves in that country; and for this purpose Louis XIV. wrote a letter to the father of the Emperor, who was then on the throne, which

* Rélation du Révérendissime Patriarche d'Ethiopie, Dom. Alphonze Mendez touchant la conversion des ames qui s'est faite en cet Empire.

† An abridged translation of this work, entitled, "Travels of the Jesuits in Ethiopia," was published in the second volume of Knapton's "New Collection of Voyages and Travels," Lond. 1711.

Abyssinia. reached him, though by what means we are not informed. At the same time instructions were sent to M. Maillet, the French consul at Cairo, to second the plans of his court; and accordingly, having learned that the Emperor was ill, he dispatched Poncet, a physician, to cure him. Along with Poncet, was sent, by the influence of the Jesuits, Father de Brevedent, a man particularly conversant in astronomy. They embarked on the Nile on the 10th of June 1698, and arrived within a day and half's journey of Gondar on the 3d of July of the following year. Here the father died, and Poncet having rested himself till the 21st of the same month, set out for Gondar. He particularly describes the public audience which was granted him by the Emperor, and his rich and splendid attire. Respecting the latter, and also in what he says concerning Gondar, his accounts are considerably at variance with the relations of the Portuguese missionaries: hence the fidelity of his work has been called in question, especially by Le Grand, though on no sufficient grounds. Having succeeded in curing the Abyssinian monarch, he set out from Gondar, in the summer of 1700, by the way of Massowa, and arrived safe in France, where he published a distinct account of his journey. A translation of it is given in *Lockman's Travels of the Jesuits*. The learned works of Ludolphus,—*Historia Ethiopica, Franck.* 1681,—*Commentarius in Historiam Ethiopicam, Franck.* 1691, and—*Relatio Nova*, &c. 1693, must not be passed over; for though he chiefly compiled them from the writings of the Portuguese missionaries already mentioned, he was enabled to add considerably to their stock of information, by means of his great knowledge of the Ethiopian language,—by his conversations with Gregory, an intelligent and liberal Abyssinian priest, whom he invited from Rome to the court of Saxe-Gotha,—and by the report of Morat, an Armenian merchant, who had often been in Abyssinia. The *Theologia Ethiopica* of Gregory is published in Fabricius's *Lux Evangelii*.

Poncet, 1699.

Ludolphus.

1750. In 1750, three Franciscans succeeded in penetrating as far as Gondar. An account of their travels is given in the appendix to Mr Salt's *Voyage to Abyssynia*, 1814. Of Mr Bruce's journey, upon which he entered in 1769, an abstract is inserted under the head Abyssinia, in the body of the work. Referring our readers to that article, we shall now proceed to examine the principal objections which have been made to the veracity of his narrative.

Mr Bruce.

Causes of the scepticism regarding his recitals.

Before Mr Bruce published any account of his travels, a spirit of scepticism respecting them had gone forth into the world, generated, partly, by the very extraordinary adventures which he recounted in conversation, and partly by a singular mixture in his character of pride and vanity, which led him at once to boast of what he had seen and done, and to deem it beneath him to remove the objections and doubts even of the intelligent and candid. This scepticism carried some so far, as to question whether he had ever visited Abyssinia; but the only point which now requires any serious discussion is, "whether his *Travels* are to be received, in every particular, as strictly true, or as a mixed work of imagination and memory?"

The second edition of this work was published after his death, by the late Dr Murray, who had access to all his journals, and the manuscripts which he had brought from Abyssinia; and it was expected by those who had considered Mr Bruce as calumniated, but too proud and obstinate to remove the calumny, that his editor, whose learning and talents were well known, would possess the means, as, no doubt, he would feel the inclination, to refute all the objections, which had been urged against him. Whether he has been successful in this respect will afterwards appear; but we must in the meantime observe, that the most zealous and partial admirer of Mr Bruce cannot censure us, if we shall try his published work by comparing it with those portions of the original journals, which Dr Murray has, with exemplary candour, given to the world. Besides this criterion, we shall compare his statements on disputed points, with the testimony of those, who have either visited Abyssinia at a subsequent period, or had opportunities of conversing with persons acquainted with that country.

Abyssinia.

1. One of the first objections urged against the veracity of Mr Bruce, was derived from his description of an Abyssinian feast. No preceding author had taken notice of some extraordinary circumstances which he mentions, though the royal feast is particularly described by Alvarez, Lobo, and Poncet. They, indeed, represent raw beef quite warm as a favourite dish on these occasions; but they are entirely silent respecting the eating of *raw flesh cut from live animals* stationed at the door; and if the practice was such, it is not easy to conjecture how it could have escaped their observation, or have been passed over in silence. Dr Murray does not give us any extract from Mr Bruce's journal, which might enable us to compare what this author actually recorded on the spot, with his published description; but contents himself with this remark on the accounts of Alvarez and Lobo, that "the practice of cutting the animal in pieces, *while alive*, readily follows;"—an inference, in which few, we imagine, will be disposed to acquiesce. As, therefore, we have no evidence in favour of the truth of Mr Bruce's narrative on this topic, either from preceding travellers, or from his own Journal, it is necessary to inquire, whether it can be confirmed from other sources. In 1788, Sir William Jones examined an Abyssinian at Calcutta, respecting the credit due to Mr Bruce; and from him he learned, that "the *country people* and the *soldiery* make no scruple of drinking the blood and eating the raw flesh of an ox, which they cut, *without caring whether he is dead* or alive; but that *this savage diet is, however, by no means general.*" Mr Salt, both in his first and second voyage into Abyssinia, made particular inquiries respecting this practice. From what he observed, during his first residence there, he was disposed to doubt the fact altogether; but, during his second residence, he ascertained, that though the Abyssinians did not feed on the *live animal at their feasts*, yet that soldiers, or peasants, on their journies, sometimes cut pieces for this purpose out of the flesh of animals which they were driving. Mr Pearce, who

His description of a Brind Feast examined.

Abyssinia. was left in Abyssinia during the interval of Mr Salt's journies, also witnessed this practice among the Lasta soldiers. The particulars of the brind feast, as they are described by Mr Salt, will be afterwards given; at present, we shall content ourselves with observing, that the statement of Mr Bruce is confirmed by Sir William Jones and Mr Salt, in so far as it goes to shew that *live flesh* is sometimes used; but that the same evidence proves the practice to have been adopted from haste and necessity, rather than from choice: and therefore does not bear out Mr Bruce's marvellous description of an Abyssinian banquet. *

There is, however, one other evidence on this point, which must be considered. Dr Clarke met an Abyssinian Dean at Cairo, whom he questioned respecting Bruce's *Travels*. The account which he gave is said to have been as follows: The soldiers, during their marauding excursions, sometimes maim cows, taking slices from their bodies, as a favourite article of food, without putting them to death at the time. During the banquets of the Abyssinians, raw meat, esteemed delicious throughout the country, is frequently taken from an ox or a cow, in such a state, that the fibres are in motion; and the attendants continue to cut slices, until the animal dies.—*Clarke's Travels*, Vol. III. p. 61.

This testimony would have been much more satisfactory and conclusive, if Dr Clarke had given us the questions which were put to the Abyssinian, as well as the substance of his reply; for it strikes us, that he was led on, either by direct questions, or by perceiving the nature of the answers which Dr Clarke anticipated, to mould his replies accordingly; and that the first part of his statement not being fully satisfactory, the subsequent parts were the result of some farther interrogations or suggestions. The reader will observe, that the Abyssinian, in the beginning of his statement, represents the *soldiers* as *sometimes* maiming a cow; he next adverts to the Abyssinian banquets; and certainly his statement, that on such occasions, raw meat is frequently taken from an ox or cow *in such a state that the fibres are in motion*, by no means leads us to anticipate the concluding circumstance, *that the attendants continue to cut slices till the animal dies*.

This view of Dr Clarke's statement, which we would not wish to be understood in any disrespectful sense, must prevent us from admitting it as a proof of the literal truth of what Mr Bruce advances; opposed, as his testimony is, both by Mr Salt and Mr Pearce, who affirm that a *banquet of live oxen* is not known in Abyssinia. Abyssinia.

The question respecting the source of the Nile stated.

2. It was early objected to Mr Bruce, that the river, the sources of which he explored, was not the main body of the Nile; and that he was not even the first European who had visited the head of its principal Abyssinian branch. It is a fact now universally admitted, that the head of the Bahr el Azergue, or Blue river, which he visited, is not that of the true Nile; and that this distinction belongs to the fountains of the Bahr el Abiad, or White river, which rise far to the south-west, among the mountains of Jibbel Kumri, in the country of the Donga. The principal branch, or Bahr el Abiad, was seen by Bruce, and is mentioned by him as a *larger* river than the Azergue; but it is nevertheless contended by his late editor, that he did not for a moment "suspect that it was the Nile." "When he left Europe," says Dr Murray, "it was almost universally believed that the Nile rose in Habbesh, and he was confirmed in this opinion by the constant testimony of the Abyssinians." But if the idea did not occur to Mr Bruce when he was in that country, that the Bahr el Abiad was the true Nile; if, ignorant that it had been pointed out as such by Ptolemy, he *then* implicitly confided in the vain-glorious pretensions of the Abyssinians, and the assuming accounts of the missionaries, he could not surely continue long in that state of ignorance and confidence, after the period of his return to Europe. D'Anville had vindicated the superior claims of the Bahr el Abiad, and had fortified his statements by the concurring testimony of Ptolemy and the Arabian geographers. Mr Bruce could not be ignorant of all this; † and when it is recollected that he himself states, in his original Journal, published, for the first time, by Dr Murray, that the "Abiad is three times as big as the Azergue," and that, but for the constant fulness of the former "the Nile would be dry eight months in the year;" it seems impossible to resist the conclusion, that he must have deliberately shut his eyes against the truth, if he did not feel, that his own observations came directly in aid of what had been advanced by D'Anville. And when we find that he preserves a total silence in regard to the statements of that emi-

* At Suez, in 1793, Mr Browne, the author of *Travels in Africa*, met an Armenian merchant, a man of intelligence, who had formerly traded to Abyssinia, and had been at Gondar while Bruce was there. He informed Mr Browne that the Abyssinians often ate raw meat, but did not mention the practice alluded to: an additional proof that it was by no means general, or even followed at their grand entertainments.

Michael, Bruce's servant, who was seen by Antes, author of *Observations on the Manners and Customs of Egypt*, at Cairo, on his return from Abyssinia, spoke of the Abyssinian practice of eating raw meat. Antes did not inquire respecting the banquet of live oxen; but is it not highly probable that Michael would have mentioned this circumstance, if he had seen or heard of it?

† It is known that Mr Bruce and D'Anville met at Paris; and Mr Pinkerton asserts, (*Geogr.—Africa*,) that the latter roundly told him, that he was far from having discovered the sources of the true Nile. But, be this as it may, it would be vain to deny, that Bruce was well acquainted with the maps and writings of the French geographer; and the most zealous of his defenders must admit it as not a little extraordinary, that he should have taken no sort of notice of an authority so eminent, and so directly opposed to the main pretension of his travels.

Abyssinia.

nent geographer, we must conclude that he did so, from a disposition to withhold from the public every piece of information that could create a doubt of his having penetrated to the true sources of this celebrated river.

The same feeling of vain glory is equally apparent in his endeavours to secure to himself the honour of having been the only European who had ever visited those coy fountains which he represents as the true springs of the Nile. We have already stated that its *Abyssinian* sources had been visited by Paez; and it is probable, though the point is certainly liable to question, that they were also seen by Lobo; but Mr Bruce equally denies the pretensions of both, and urges a variety of objections to their narratives, which are now admitted, at least with regard to the former, to be wholly groundless. Dr Murray candidly admits that the first discovery was made by Paez; and, indeed, when we reflect that both these missionaries resided for a long time in Abyssinia—that the latter spent some time in the province of Damot, near the supposed source of the Nile—that they must certainly have had some curiosity to examine it—and that they coincide with Mr Bruce in his description of a number of minute and local particulars, we must concede them the honour, such as it is, of having made this discovery.

But Mr Bruce was jealous, not only of preceding travellers, but also of his own attendants. In his *Travels,* he dates the death of Luigi Balugani in *March* 1770; and yet he states that Abba Salama, whom he represents as attempting to raise the populace at the funeral of Balugani, was executed for high treason on the 24th of *December* 1770. Besides this direct contradiction, it appears by the journals, kept in Italian by Balugani, from which extracts are given by Dr Murray, that he was alive at Gondar in February 1771. This gross mistatement it is vain for his editor to ascribe to an imperfect and confused memory. Another cause, originating from the paramount failing of his character, is but too obvious. In his account of his journey to the sources of the Nile, he is particularly anxious to impress the reader with the idea, not only that no European had ever before visited them, but that he was not accompanied by any European:—is it therefore unwarrantable to suppose that the death of Balugani was antedated a twelvemonth, to deprive him of the honour of having accompanied his master on this occasion? That he did actually accompany him is proved by the Journals in question.

Some of his journies questionable.

3. Mr Bruce, in his *Travels*, mentions, that, on the 25th of December 1768, he arrived at Dendera, whence he proceeded by Badjoura and Farshout to Thebes; from which place he proceeded, on the night of the 7th of January 1769, to Luxor, where he remained till the 17th, and on the 20th arrived at Syene, from which place, descending the Nile, he returned to Badjoura on the 2d of February. The narrative of this journey from Luxor to Syene is not only minute in dates, but it is filled with the most circumstantial and amusing adventures; and yet, that it never took place, is rendered almost certain; for it appears from his *Journal*, that he arrived first at Farshout, and afterwards at Dendera, on the 7th of January, the very day assigned in his Travels for his departure from Farshout. According to the latter, he remained at Syene from the 20th to the 26th; according to his journal, he was at Badjoura on the 22d and 23d; and no mention whatever is made of a journey from Luxor to Syene, nor, indeed, if his journal be correct in the dates and places, could he have performed it. Besides, in his letter to Mr Wood, dated Gondar, March 1, 1770, he expressly says, "From Luxor we *returned* to Badjoura;" thus confirming his Journal, and contradicting his *Travels.*

Nor is this the only instance of the interpolation of an apparently fictitious journey. According to his *Travels*, Mr Bruce, on the 26th of July 1769, sailed from Loheia, on the Red Sea, to the Straits of Babelmandel, and returned to Loheia on the 6th of August; yet, by his *Journals,* it appears that two observations were taken at Loheia on the 5th of August, while the voyage, and the observations taken during it, and inserted in the Travels, are not mentioned. The journals of Luigi Balugani are equally silent regarding this voyage; but they detail the dates, &c. of the voyages from Cosseir to Jimbo and Jidda; from Jidda to Loheia; and from Loheia to Massowa; nor does any one of the twenty charts or drawings taken by this artist in the Red Sea relate to the voyage from Loheia to the Straits of Babelmandel. In his account of this fictitious voyage, he seems to have trusted to the authority of Faden's map, as the latitudes and relative situations of the places he mentions as having passed or visited agree with that map; which, according to Mr Salt, is erroneous.

Nearly an equal degree of suspicion hangs over the voyage from Cosseir to Jibbel Zumrud and Macowar. The latitude assigned by Bruce to Jibbel Zumrud is erroneous by upwards of a degree; and Macowar is in 20° 38′, not in 24° 2′. In the Journals there is not a single observation of latitude at either of these places; nor do any of the charts or drawings relate to this voyage. The account of the emerald pits is also very improbable.

Respecting the accuracy of Mr Bruce's chart of the Red Sea, the opinions of those who have sailed in that sea, and compared the actual situation of the places with the chart, differ considerably. According to Dr Clarke, General Baird, and the officers who attended him in the expedition up the Red Sea, for the purpose of expelling the French from Egypt, expressed themselves in high terms regarding its accuracy. Their evidence, however, is too vague and general to be of much value. On the other hand, Lord Valentia, who had along with him one of the best surveyors now living, Captain Charles Court, Surveyor-General to the East India Company, represents it as by no means accurate; and further remarks, that there is a surprising and suspicious coincidence between the latitudes assigned by Bruce and Niebuhr to the same places, though the one took them by land and the other by sea; the instruments at that time being too imperfect to secure such a coincidence, even if both the observers had travelled by land, and used the same degree of skill and attention. Indeed, the instrument which Bruce made use of, a large and unwieldy French quadrant, must

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not only have been very liable to have been put out of order, but likewise unfit for the use of any except a very able astronomer.

Instances of his exaggerations.

4. The strong tendency which Bruce possessed, from the predominant feelings and passions of his nature, to exaggerate and introduce fictitious narratives, has already been established on some very important points. There are, however, a few subordinate and miscellaneous instances of this tendency, which may be noticed. The detection of them rests on the authority of Mr Salt; and none, we imagine, will hesitate to prefer his testimony to that of Bruce, respecting what both have actually seen, or had equally good opportunities of ascertaining, after the instances of Mr Bruce's inaccuracy already given; resting, as they do, on evidence and proofs quite concurrent and conclusive, though totally independent.

Mr Salt asserts that Mr Bruce's representation of the Obelisk at Axum is very erroneous, and his description of the ruins at that place greatly exaggerated. His description of the Tigrè Mountains as resembling "pyramids pitched upon their points, with their base uppermost," called for such a large portion of faith, that we scarcely needed the authority of Mr Salt to disbelieve it, and pronounce it extravagant and untrue. His account of the discovery of the Emperor Joas's body is greatly embellished, and is inaccurate in the dates, as well as in many of the circumstances.

Dofter Esther, a learned Abyssinian, who resided at Gondar all the time that Bruce was in Abyssinia, and was intimately acquainted with him, informed Mr Salt, that Amha Yasous, Prince of Shoa, never visited Gondar during Mr Bruce's abode in that city, as Bruce mentions in his Travels, *but not in his Journal;* and Mr Salt adds, that the story of the book, for which the Prince sent in order to give it to Mr Bruce, is highly improbable; as by referring to Mr Bruce's dates, it will appear, that unless the original was sent, (which, considering its value and rarity, is extremely unlikely,) it must have been brought a distance of five hundred miles, and been copied in a fortnight. Dofter Esther also informed Mr Salt, that Mr Bruce did not speak the Tigrè, nor much Amharic; and that, with the exception of one battle, he was never engaged in war during his abode in Abyssinia. This is confirmed by the original Journal, (Vol. VII. p. 69.) It is right to add, that this learned person spoke very highly of Mr Bruce, and confirmed his accounts in almost every other particular, on which Mr Salt questioned him, except such as have been just stated.

Regarding the district which Mr Bruce says was assigned to him in Abyssinia, the authorities are at variance. The Armenian merchant whom Mr Browne met at Suez, in the year 1793, and who had been at Gondar while Bruce was there, as well as the Bergoo merchant, whom Mr Browne saw at Darfoor, and who had been in Bruce's party from Gondar to Sennaar, informed Mr Browne, that Bruce had been governor of Ras-el-fil; whereas Dofter Esther and others expressly stated to Mr Salt, that no district had been given him; and all the persons whom Mr Salt conversed with during his first journey into Abyssinia agreed in saying that he never was governor of Ras-el-fil. *

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His statements respecting the eclipse of the Moon examined.

5. The accuracy of Mr Bruce's statements respecting the change of the moon at Farshout, and its eclipse at Feawa, has been strongly attacked; and Mr Bruce himself, in his corrections for a second edition, has endeavoured to evade the objections by what appears too like an arbitrary alteration of the text, made for that express purpose. In the first edition, Mr Bruce predicts the eclipse *before* four o'clock—*el' asser.* Dr Rotheram, by a calculation of the eclipse for the meridian of Feawa, proved, that at the hour when Bruce asserts the eclipse had advanced some way, and was apparent upon the disc, it was not visible at Feawa; as the moon was then many degrees below the horizon, and rose almost in the very middle of a total eclipse. In the second edition, "*before* el asser," is altered to *after* el asser; and Dr Murray observes, that the Arabic word *el asser* comprehends indefinitely the whole evening. But not even this, and the other trifling alterations which are made in the second edition—nor the apology of the editor, that Mr Bruce's memory, at the distance of fourteen years, deceived him, will remove the objection, when we remark the great difference of time between the reality and his description of the eclipse; and learn, moreover, that in De la Caille's *Ephemerides*, which Mr Bruce carried with him, the day on which this eclipse happened, is marked by Mr Bruce, and that 2 hours 25′ 36″ is the time, when, according to the Ephemerides, the eclipse would commence at Paris. Is there then not reason to believe, that he was led into this mistake by not adverting to the great difference of time between Paris and Feawa? for that, if he did actually predict the eclipse, he predicted it as to happen *before*, and not *after* el asser, is evident, from the following circumstance: On that day Mr Bruce attended the Shekh about nine in the morning, and after a large breakfast, he repaired to the market-place, where he exhibited some feats of horsemanship, and promised to return in *something more than two hours*, when the sign should appear.

General estimate of his accuracy.

Such are the principal objections which have been urged against the truth and accuracy of Mr Bruce's narratives. His book has certainly undergone a more minute and severe examination than any other work of the same description. Those parts, therefore, which have come out of this ordeal untouched, may fairly be regarded as unexceptionable; and if we compare what has been proved to be erroneous, with what not even the keenest, most intelligent, and best informed of his critics have dared to question, we shall find that the unchallengeable additions which he has made to our knowledge are great and valuable. But the proofs of his *general* accuracy are not merely of this ne-

* It is not improbable, however, that the governor of this province, who was Mr Bruce's particular friend, might have given him permission to assume the nominal command of it.

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gative description; there are others of a more direct and satisfactory nature, which we shall briefly notice.

Mr Salt, though he justly regarded it as a duty he owed to the world, to point out the mistakes and exaggerations of Mr Bruce, yet bears ample and willing testimony to the general accuracy of his descriptions and narrative; and records, in more than one instance, the astonishment which the Abyssinians expressed at the knowledge which Mr Bruce displayed of their history and country. Mr Browne and Mr Antes, who, as has been already noticed, had excellent opportunities of comparing Mr Bruce's statements with the accounts given by persons well acquainted with Abyssinia, bear testimony to the general accuracy of his details; and Dr Clarke, while at Cairo, obtained from the Abyssinian Dean, of whom we have spoken before, direct and specific evidence in favour of the correctness of some parts of his narrative, which had till then been regarded with suspicion. The plates given in Mr Bruce's *Travels*, especially those of natural history, were early represented as inaccurate; that they may be so in some of the minutiæ is not improbable, as Bruce laid no claim to a scientific knowledge of the subject; but when Dr Clarke shewed the Abyssinian Dean these plates, though he knew not the nature of the book in which they were contained, and the name of Bruce was not mentioned; the latter immediately gave the same appellations, and assigned the same uses as Bruce, to the *Ergett-denimo*, *Eyett el kroné*, *Emsett*, *Kolquall*, *Gergir*, *Kantuffa*, &c. He is said to have borne testimony to the accuracy of the plates of the quadrupeds;* and, what is of more importance, both to Bruce's credit and to natural history, he confirmed the account of the *zimb* fly, and asserted that he had heard of armies being destroyed by it. When Bruce's map was laid before him, though of course he could not read the names, he pointed out the locality of Gondar, exactly where Bruce had placed it.

A considerable period elapsed between the date of Mr Bruce's travels, and those of Mr Salt, the next European traveller in Abyssinia; and Mr Browne informs us, that, for nine years preceding 1796, there was even no communication between Egypt and that country, probably in consequence of the unsettled state of Sennaar and Nubia.

Mr Salt's first journey.

Mr Salt's first journey into Abyssinia took place in the year 1805. Having accompanied Lord Valentia in his travels in the East, and his Lordship being desirous of ascertaining the state of Abyssinia, and the probability of opening a commercial intercourse between it and Britain, and her oriental dominions, Mr Salt undertook the conveyance of some presents from his Lordship to the Ras. An abstract of the most important information contained in both his journeys will afterwards be given; at present we shall confine ourselves to a brief outline of his route. From Massowa he proceeded to Arkeeko; and thence southwards, with a little inclination to the west, he passed over Taranta to Dixan. On leaving this place, he directed his journey to Antalo through Abha, Agowma, and Chelicut. At Antalo he found the Ras, and delivered Lord Valentia's presents. From Antalo he made an excursion to Axum, by the route of Mucullah and Adowa, at which latter place he met with Fasilydas, the son of Yasous, formerly king of Abyssinia. At Axum he particularly examined the obelisks, inscriptions, and ruins; he also discovered a Greek inscription fifteen hundred years old, which proves Axum to have been the capital of a people called the Axumites, and gives credibility to the accounts before doubted, of embassies sent to them by the Romans. This inscription fixes the conquest of part of Arabia by the Abyssinians at an earlier period than was hitherto supposed. From Axum Mr Salt returned to Antalo by the road he came; and on his leaving the country, he again visited Axum and Dixan.

Excursions of Mr Pearce in Abyssinia.

Mr Pearce, one of his attendants, was left behind at Antalo; and when Mr Salt arrived in Abyssinia the second time, about five years afterwards, he learnt from Mr Pearce, that, during his residence in that country, he had made an attempt to reach Gondar. For this purpose he set out from Antalo, and directed his course through the province of Wojjerat; a plain inhabited by negroes, called Doba; and a district of the Galla tribe. Soon afterwards he reached the town of Mocurra, and the village of Dufât on one of the high Lasta mountains; his course during the whole of this part of his journey was nearly south. After passing the village of Dufât he arrived at the town of Senare, and visited the sources of the river Tacazze, having before this met with no stream of importance. He now changed his route, following the course of the river, nearly due north, and afterwards north-east to Socota, the reputed capital of Lasta,—the district which, before his departure from Antalo, he was advised to pass through, as lying in the most accessible road to Gondar. From Socota, he proceeded northwards along the banks of the Tacazze, and, having crossed it, entered the province of Samen, the mountains of which he ascended till he reached Mishekka, and afterwards descended them to Inchetkaab, where Ras Gabriel resided. Here, having learnt that Ras Melud Selasse, with whom he had been left by Mr Salt, at Antalo, was in danger of being attacked by the Galla, he returned to that town by a more direct route, than he pursued in his journey to Inchetkaab. His next excursion was, in company with the Ras, against his enemies, through Lasta, and the Galla having been defeated, into the plains of the Edjow. Next year, engaging again in the campaign, he accompanied the army into Hamazen. He also passed over the salt plain by Omphila. These were the principal parts of Abyssinia, which Mr Pearce had an opportunity of visiting, during the interval between Mr Salt's departure from, and return to that country.

* There must surely be some mistake here, as the plate of the rhinoceros is evidently borrowed from Buffon, with the addition of another horn, and exhibits folds in the skin; a circumstance never existing in the two-horned species, though always met with in the one-horned, which alone Buffon describes.

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Mr Salt's second journey.

Mr Salt, in his second journey, proceeded from the coast of the Red Sea, by the route of Wéah, to the foot of the Taranta mountains, which he crossed to Dixan, and thence proceeded to Chelicut. Here he ascertained that it was impracticable to accomplish the immediate object of his journey,—the personal delivery of the presents with which he had been entrusted by his Majesty to the Emperor of Abyssinia,—as that monarch lived entirely neglected, and in fact a prisoner at Gondar, which was in the possession of Guxa, a chief of the Galla, and the decided opponent of Mr Salt's friend, Ras Welud Selasse. Disappointed in this object, he made an excursion to the Tacazze, through the province of Avergale, a distance of sixty miles west from Chelicut; and on his return to the latter town, he made another excursion to Antalo. On finally quitting Chelicut, he passed through the high district of Giralta, whence he descended the steep pass of Atbara, to the banks of the Warrè. His route was next to Adowa, over several ridges of hills. From Adowa he made an excursion to Axum, for the purpose of re-examining its ruins and inscriptions. Having accomplished this object, he returned to Adowa, and thence to the sea-coast.

From this brief outline of Mr Salt's two journies, and of the excursions of Mr Pearce, it will appear that neither of them penetrated so far into Abyssinia, as Mr Bruce had done; nevertheless, their narratives are of very considerable value, not only on account of the new information which they supply, but also, as they enable us to place more steady confidence in such parts of Mr Bruce's statements regarding Abyssinia, as they had the opportunity of verifying; and to ascribe to his *Travels* their just degree of value and accuracy.

Present state of Abyssinia.

II. We come now to the second division of our subject,—the additional information regarding Abyssinia, supplied by Dr Murray's edition of Bruce, and by Mr Salt's two journies.

Divisions.

When Mr Salt was last in Abyssinia, it was divided into three distinct and independent states. *Tigrè* which was the most powerful, was under the dominion of Ras Welud Selasse, who possessed the monopoly of all the muskets imported, and of all the salt. Tigrè comprehends about four degrees of latitude, and the same of longitude; it possesses the sea-coast, is naturally strong, and is inhabited by a warlike people. Its divisions are, 1. Tigrè proper; the general character of which is, a range of hills, intersected by deep gullies, and cultivated plains. 2. Agamè, which lies to the east of Tigrè proper. This division, being level land, at a considerable height above the sea, and consequently enjoying a favourable climate, is rich and fertile. On its eastern frontier, and near the Taltal, it is strong; the salt plain is in its vicinity. 3. The division of Enderta, to the south of Agamè, is mostly mountainous; its capital is Antalo, in which the Ras resides, on account of its being situated so as to protect the southern provinces from the Galla. 4. To the south of Enderta is the division of Wojjerat; a wild district, full of forests, in which the lion, elephant, and rhinoceros are found. 5. Adjoining to Wojjerat, is the small and low division of Wofila, which borders on the lake Ashangel; here the Galla are intermixed with the native Abyssinians, and profess the Christian religion. 6. The division of Lasta is rugged, and almost entirely composed of inaccessible mountains. To the north of this there are two mountainous districts; and between them and the Tacazze are two low districts, inhabited by Christian Agows. 7. Further to the north lies the division of Avergale. It is very narrow, and stretches, for about fifty miles north and south, along the Tacazze. It is inhabited by the Agows. 8. The division of Samen, which is to the east of the Tacazze, is the highest land in Abyssinia. Its mountains run north and south, about eighty miles. 9. Between the northern border of Samen and Tigrè proper, lies the valuable district of Zemben. 10. Above Zemben, to the west of Axum, is the division of Shirè, the most picturesque part of Abyssinia, abounding in rich vallies, flowery meadows, and shady groves. 11. The last division of Tigrè is commonly called the kingdom of the *Baharnegosh*.

The *second* independent state is that which still retains the name of *Amhara*. This is almost entirely in the possession of the Galla, whose chief is Guxo, the enemy of Ras Welud Selasse. His power, on the west side of the Tacazze is absolute; and it is much strengthened and increased by his connection with the southern Galla; his cavalry are estimated at twenty thousand, chiefly from the district of Begemder. Gondar belongs to him.

The *third* grand division, which lies in the south of Abyssinia, is now entirely separated from the two others by the Galla; it consists of the united provinces of *Shoa* and *Efat*, which are supposed to retain a larger portion of Ethiopian literature and manners than any other part of Abyssinia. Efat lies between the ninth and eleventh degrees of latitude. It is principally high land, running north and south, and gradually declining on each side into a plain country. Streams flow from both sides of the mountains, and fall into the Nile and Hawush. Two branches of the latter nearly encircle this province. The present ruler is the grandson of Yasous, mentioned by Bruce, (but as Dofter Esther informed Mr Salt, incorrectly) as having visited Gondar, while he was there. He resides at Ankober, the capital of Efat. This district is one of the finest in Abyssinia, and in power equal to that of Ras Welud Selasse. Its force is chiefly cavalry, who are very skilful and courageous. The province of Shoa lies on a lower level than that of Efat; there is extremely rich pasturage in its vallies; it contains several large towns, and many monasteries. The districts of Walaka and Gondar are dependent on the united provinces of Shoa and Efat.

Rivers.

Of the rivers, the Tacazze is described in the original work: from Mr Salt we learn, that it rises from three small springs in the plains of Margilla; that in the rainy season, it is swelled by the torrents; that it is joined by the river Arequa, which runs through the province of Avergale, in a north-west direction, in the district of Zemben; and that it forms one of the larger branches of the Nile. The Bahr-el-Asrek, or Blue River, or Azergue, the chief Abyssinian branch of the Nile, rises from two foun-

tains in Sacala, near Geesh, flows through the lake of Dembea, sweeps in a semicircular direction round the provinces of Damot and Gojam, when it quits the lake, and unites with the Bahr-el-Abiad, or White river, at Wed Hogela, in latitude 16. This river, the real Nile, is supposed to rise in the Jibbel-el-Kumri, or mountains of the Moon. The other rivers are, the Maleg, which joins the Abyssinian Nile, after a parallel course, on the west; the Mareb, which forms the boundary between Tigrè and the kingdom of the Baharnagosh: the Hanazo and Hawush, which flow in an opposite direction, towards the entrance of the Red Sea, and the Jemma. The principal lakes are Dembea, or Tzana, about sixty miles long, and thirty broad, where most extensive, and in the wet seasons; the lake of Lawasa, in the southern extremity of Abyssinia, a chief source of the Hawush; the lake of Haik, near the rocks of Geshen and Ambazel, and the Ashangel.

The mountains of Abyssinia are described in the original work.

Natural History.

Our knowledge of its natural history is considerably increased by Dr Murray's edition of Bruce, and Mr Salt's two journies; but we must confine ourselves to a brief notice of the most important particulars.

Botany.

The *lehem*, or *Toberne montana*, a tree common near the lake of Dembea, is remarkable for its beauty and fragrance; it grows to a considerable size, the extremities of its branches trailing along the ground, loaden with flowers, from top to bottom, in great profusion, each cluster containing between eighty-five and ninety, open or shut: the fruit is eaten, but has rather a harsh taste. The *anguah*, found near the Tacazze, produces a gum resembling frankincense. The leaves of the *gheesh*, which is very common, are put by the Abyssinians into their maize: they are likewise reduced to powder, and mixed with the other materials of which they make *sowa*. The *mergombey*, a species of *Solanum*, is used as a cathartic; and from the *niche*, or *niege*, they extract their vegetable oil: it is a species of *Sesanum*. These are the principal plants, descriptions and plates of which are given from Mr Bruce's manuscripts and drawings by Dr Murray. Mr Salt's researches have added eight new genera, and one hundred and twenty-four new species, to botany. Near Shela, a species of narrow-leaved *Ficus* grows, called by the natives *chekunit*; the inner rind of the bark of which, having been bruised on a stone, twisted round a stick, and dried, is used as matches for their fire-arms. Near Adowa, Mr Salt found a new and beautiful species of *Amaryllis*, bearing ten or twelve spikes of bloom on each stem, from one receptacle, as large as those of the *belladonna*. The corolla is white; each petal is marked down the middle with a single streak of bright purple; it is sweet-scented, like the lily of the valley; the bulbs are frequently two feet under ground. Mr Salt brought this plant to England.

Animals.

The domesticated animals are oxen: the Galla oxen, or *sanga*, were not seen by Mr Bruce; and his account of them is not strictly correct, their large horns not being the effect of disease. The largest Mr Salt ever saw was four feet in length, and the circumference at the base twenty-one inches. The horns of one of them are in the museum of the College of Surgeons in London. The animal itself is of the usual size, and of various colours; it is by no means common in Abyssinia, being brought only by the *cafilas*, or salt caravans, as a valuable present, from the south. Sheep,—these are small and black; goats; horses, strong and beautiful; mules, asses, a few camels, two species of dogs, one of which owns no master, but lives in packs in the villages, like the paria dog in India; the other is kept for game, especially for Guinea fowls, which it catches very expertly: tame cats are found in every house.

Wild Animals.

The wild animals are the elephant, which is hunted by the Shangalla for their teeth; the cawe leopard, rare, only found in the interior districts; very shy; its skin is an article of barter: the two-horned rhinoceros, also rare, only found in the forests of Wojjerat, and the low land near the Funge; its horns have no connection with the bone of the head, consequently the opinion of Sparman, that they can raise and depress them at pleasure, may be correct. This rhinoceros has no folds in the skin, as the one-horned has; its skin is used for shields; its horns for handles to swords and daggers; and, according to the Abyssinian Dean, whom Dr Clarke interrogated at Cairo, as a lining to drinking-vessels, being regarded as an antidote to poison. The foremost horn is two feet long, and very large in other respects. The buffalo is very common in the forests of Ras-el-fil; shields are made from its skin with great art. The zebra, in the south chiefly; its mane decorates the collars of the war-horses belonging to chiefs of great rank, on days of state. The wild ass is found in some parts; lions occasionally, especially in the sandy districts near the Tacazze. Whoever kills one wears the paw on his shield; the skin, richly ornamented, forms a dress like that worn by the Caffre chiefs. There are several species of leopard, one black, extremely rare, the skin of which is worn only by governors of provinces. The lion-cat, tiger-cat, or grey lynx, and wild-cat, are not uncommon. From the libet, civet is procured, and is an article of commerce. The hyena: Mr Salt remarks that it has a singular cry; three distinct deep-toned cries; then silence for a few minutes, succeeded by the same kind of cry. The hyena and dog seldom fight; they even feed on the same carcase: a small kind of wolf; common fox; sea fox; and jackall. There is a great variety of antelopes, one of which is probably allied to the chamois, being confined to the cold and mountainous district of Samen. Several species of monkey; the wild boar; porcupine; cavy, nearly allied to that of the Cape; a small grey hare, deemed by the natives unclean; squirrel; rats, very numerous in the fields; an undescribed species of lemur, the size of a cat, with a long tail, faintly striped with black and white, with white bushy hair at the end: the hair on the body is long, and of a clear white, except on the back, where there is a large oval spot, covered with short, deep black hair. Of this every man in Tigre endeavours, if possible, to have a piece on his shield. The hippopotami are chiefly found in the deep pits, like lochs, between the fords of the Tacazze; they roll and snort like a porpus; they cannot remain longer than five or six minutes under water: their colour is a dusky brown, like the elephant; their usual length sixteen

Abyssinia. feet. Whips are made of their skin, and used to brush away the flies, which are very troublesome in hot weather; the butt-ends of the whips are ornamented with hair from the tail of the cameleopard.

Birds. Besides the two species of Falco, described by Mr Bruce, there is another called *goodie-goodie*, the size of the common falcon, the feet and back bluish, the general colour a deep brown, the whole of the breast a clear white. Mr Salt also found a new species of vulture. The ostrich is rarely met with in Abyssinia, except in the low districts to the north. The hern is common in marshy ground. The hornbill, in the cultivated lands of Tigrè, destroys the grubs, &c. builds in low branches of lofty trees, and is often seen solitary. The Egyptian goose, allied to the *Anas Lybica*, is occasionally seen. Guinea fowls, partridges, quails, &c. abound.

Rare Birds brought home by Mr Salt. The rarest birds brought home by Mr Salt from Abyssinia are a new species of *Bucco*, since called *B. Saltii*, which clings like the woodpecker to the branches of trees; a variety of the *Upupa erythrorhynchos*, with a black tail; it feeds on the figs of the *Ficus sycamorus*; a non-descript species of *Merops*; a non-descript species of *Tanapa*, which perches on the backs of the cattle, and feeds on the grubs which infest them in hot weather; the *Columba Abyssinica*, wild among the daro trees, eaten by the Abyssinians; the *Tringa Senegalla;* the *Erodia amphilorsis*, allied in some degree to the *Arodea Pondiceriana*, probably a new genus; the *Cursorius Europœus*, an extremely rare bird, shot on the sandy plains near the Tacazze.

Bees. Bees are domesticated in the province of Wojjerat, which is famous for white honey, sold at Antalo. Mr Salt gives a dreadful account of the ravages of the Abyssinian locust.

Mineralogy. Little is still known respecting the mineralogy of Abyssinia. Near Wéah there are low hills of granitic rocks, resting on a bed of micaceous earth. In the district of Tigrè the soil is sandy; the rocks, composed of slate, schistus, and granite, lie in perpendicular strata. In the districts of Geralta and Enderta

Salt Plain. the strata are rather horizontal. But the Salt Plain is the most interesting, not only in a mineralogical, but also in an economical view, as from it the Abyssinians obtain the pieces of salt which they use as money. This plain lies near the country of the Assa Durwa, about fifty miles west of Amphila, on the road to Massowa; it is about four days' journey in extent from north-east to south-west: it is crossed in sandals made of the leaves of a species of palm. The plain is perfectly flat; for the first half mile the salt is soft; it then becomes hard and crystallized, like ice on which snow has fallen, after it has been partially thawed; branches of pure salt occasionally rise above the surface. It is cut with an adze into pieces the shape of a whetstone. For about two feet immediately under the surface it is hard and pure; afterwards it is coarse and softer, till exposed to the air. The employment of cutting the salt is very dangerous, on account of the Galla, who frequently attack the workmen; none, therefore, are employed except the lowest order of the natives, who lie down on their backs, or flee to the mountains, on the approach of the Galla. Salt caravans, called *cafilas*, are regularly sent for salt from Antalo; and the Balgudda, or protector of these caravans, is a situation of great importance as well as emolument; for on their safe arrival mainly depends the internal and external commerce of the Abyssinians: when they arrive, therefore, they are received with great acclamation and joy. The Galla frequently attack them. The emolument of the Balgudda is derived from the duty imposed on the importation of salt;—a camel, the usual load of which is two hundred pieces, pays eleven; a mule, carrying eighty, pays nine; an ass pays six; when it is brought away by men, no duty is paid.

Climate. With respect to the climate, Mr Salt found that the thermometer, in March, April, and May, averaged 70° at Chelicut, 65° at Antalo, 95° on the banks of the Tacazze, and on the mountains of Samen, he supposed it to be below the freezing point. He contradicts, from his own observation, Mr Bruce's statement, that snow is not known in Abyssinia: on the mountains it is not uncommon. The Samen mountains were covered with snow at the time Mr Salt saw them; and Mr Pearce, in his passage over them, experienced a heavy fall.

Agriculture. Two varieties of wheat are cultivated, of which they make large loaves, either baked or prepared by steam. These, however, are used only at the tables of the great. The *teff*, which is their usual food, varies in colour from white to black. The Abyssinian Dean informed Dr Clarke that beer, or *soua*, was made from *selleh*, and not from *teff*; and that it is not made from the latter, is confirmed by the testimony of Michael, Mr Bruce's servant. (*Murray's Life of Bruce*, 4to. p. 252). The *neug*, which is like the Raggy of India, is next in esteem to the *teff*, with which, or with barley, it is mixed to make bread. It is harsh and dry. Two kinds of barley are sown, the black, in great quantity, but it is only given to horses and mules. Maize is much cultivated between Galla and Dixan, but not made into bread. The vetch is cultivated for the purpose of mixing it with teff, or forming it with ghee and curds into balls. It is eaten in the morning. The worst grain of every kind is generally used for seed. As almost every man cultivates enough for his family, it is seldom sold. On the low lands there are two crops. The ploughs are rudely made, from the root or branch of a tree; sometimes the shares are of iron. They are drawn by oxen. The land is twice ploughed, afterwards the clods are broken by women, and when the corn is half ripe, it is weeded by men, women, and children, singing as they work; only females reap, and when strangers pass they utter a sharp shrill cry, the Liralect of Syria, where it is used on the same occasion. It is caused by trilling the tongue against the roof of the mouth, without any distinct words, but a constant repetition of the syllable *al*, uttered with the utmost rapidity. In some parts, the grain, when carried, is secured from the weather by means of tanned kid skins. The plain of Larai, near Dixan, resembles the vale of Evesham. It is highly cultivated, and irrigation is practised in it. Cotton is grown near the Tacazze, and sold at Adowa.

Customs, &c. Of the customs, manners, superstitions, laws, and languages, of the Abyssinians, and the neighbouring tribes, noticed by Mr Salt, the following are the

Abyssinia.

Brind feast.

most curious and interesting. His description of a brind feast, though not so highly coloured as that of Mr Bruce, is still sufficient to prove the barbarism of the Abyssinians. The sides of the table are covered with piles of thin cakes made of *teff*, reaching to the height of a foot, and two feet and a half in diameter; in the middle a row of curry dishes is placed. Near the Ras there are a number of fine wheaten rolls, for his own use, and that of his favourites. The signal to begin the feast is given by his breaking and distributing them; immediately female slaves, having washed their hands, dip the *teff* into the curry, and serve it to all the guests, except the Ras, who receives his portion from a male slave, and afterwards distributes it among the chiefs, who acknowledge the favour by standing up and bowing. Balls composed of teff, greens, and curds, are next handed about. In the meantime the cattle are killing in the adjoining yard. The process of killing is simple:—the beast is thrown on the ground, and its head separated from the body with a Jambea knife, during which an invocation is always pronounced. The skin is immediately stript off one side, and the entrails being taken out, are devoured by the attendants. While the fibres are yet quivering, the flesh is cut into large pieces. These are of no regular size; but generally a piece of bone is attached to the flesh, by which it is brought into the dining-room. The chiefs with their crooked knives cut off large steaks, which they divide into long stripes, half an inch in diameter. If they are not pleased with the piece they have got, they hand it to a dependant, who, in his turn, if not pleased, hands it to another, till it comes to one whose taste or rank does not induce or authorize him to reject it. As soon as the first party is satisfied, they rise from the table and give way to others. The last cakes are scrambled for with a great noise. It appears from Mr Salt, that, though the chiefs sometimes feed themselves at these feasts, yet more frequently, as Mr Bruce relates, they feed one another.

Live meal.

It has already been mentioned, that Mr Pearce witnessed a live meal, when travelling with the Lasta soldiers. Having fasted long, one of thom proposed to cut out the *shulada*, upon which the cow was thrown down, and two pieces of flesh, weighing about a pound, cut from the buttock; these they called the *shulada*. Whenever Mr Salt mentioned the term, he was always understood. After the pieces were cut out, the wounds were sewed up, and plastered over with cow-dung. The animal was drove on, but killed at the end of the journey. The Abyssinians are very expert in dissecting a cow, as there are always a number of claimants, each of whom claims a right to a particular portion.

Pictures.

The Abyssinians are very fond of pictures. Their churches are full of them, and such chiefs as can afford it, ornament the walls of their principal room with them. They paint their pictures on the surface of the walls, tracing the outline with charcoal; they afterwards go over it with coarse Indian ink, and lastly, introduce the colours, which are almost exclusively gaudy. They exaggerate the size of the eye, and paint all classes with full faces, except the Jews, whom they uniformly paint with side faces.

On their journeys, they sing extempore verses, one person alone composing and singing them at first, after which they are repeated in chorus by the rest.

Dress.

Their dress consists of a large folding mantle, and close drawers. To these the priests add a vest of white linen next the skin. On their head they wear a small shawl of white cotton, with the crown exposed.

Houses.

Their houses are of a conic form, covered with thatch. In Dixan the houses are flat-roofed, without windows; instead of chimnies are pots of earthen ware on the roofs. There are also caves near this place used as dwellings, which are expeditiously made, in a very simple manner: the earth being dug out, and the mortar tempered occasionally with the blade-bone of an ox, and the stones that are used shaped with an adze.

Drink.

Their principal liquor is called maize, made of honey fermented with barley, and strengthened with the root of the *Rhamnus inebrians*, called *sadoo*. The liquor is drank out of Venetian decanters, called *brulhes*. But the common drink among the lower class is made of the bread left at their feasts, and parched barley; it is called *sowa*, and is drank out of horns.

Marriage.

Marriage is generally a civil contract. The female, who is seldom consulted on the occasion, is carried to the house of her husband on his shoulders, or those of his friends. The bride and bridegroom are sometimes seated on a throne of turf, shaded with boughs, round which the relations, &c. dance. The dowry consists of gold, cattle, musquets, and cloth, and is always kept apart, and returned in case of separation. Marriage by civil contract can be dissolved at pleasure; by religious contract it is more sacred, especially when the parties take the sacrament after marriage. Ladies of rank retain their estates and maiden names, and assume great superiority over their husbands. At Dixan they allow the nails on their left hand to grow to a great length, and cover them with cases of leather to preserve them. In some parts it is not uncommon for one man to have several wives; only one, however, is deemed his lawful wife; each has her separate residence.

Treatment of the dying and dead.

When a person is seized with a species of fever called *Tigrè-ter*, his relations shew him all the gold and silver ornaments, fine clothes, &c. which they can collect, making, at the same time, a dreadful noise with drums and other musical instruments, to drive the devil out; for they believe all diseases come from the devil. When death is at hand, the drums, &c. cease; and when it actually takes place, howling and tearing of the hair and skin from the temples ensue. No time is lost in washing the body, and fumigating it with incense, after which it is sewed up in the clothes of the deceased, and buried in great haste.

Feast of the dead.

When the burial is over, the *toscar* or feast of the dead commences; an image of the deceased, in rich garments, on his favourite mule, is carried through the town, accompanied by other mules, &c. in gay apparel, and by female hired mourners, crying out, as in Ireland, "Why did you leave us? had you not houses and land?" When the procession returns, cattle are killed, and an immense number of people feasted; a repetition of this feast, at certain intervals, is given by the different relations

Abyssinia.

of the deceased, who vie with one another in profusion and splendour.

Punishments.

When a person is murdered, the criminal is generally given up to the relations of the deceased, who take him to the market-place, and dispatch him with their knives and spears, every relation and friend making a point of striking a blow. When a person accused of any crime is apprehended, he is tied by his garments to another; and it is always considered a sure proof of guilt, if he runs away and leaves his garments behind. The Ras decides disputes: before him each party makes his statement, and stakes a quantity of salt, a mule, slaves, gold, &c. on the veracity of his statement; the party convicted is punished by the forfeiture to the Ras of what he staked. Lands descend from father to son; when there is no son, they go to the brother. All the children and relations have a claim on the property of the deceased; if he has neither, he generally directs it to be sold, and one half to be given to the priests, and the other to the poor.

Lent.

Their lent continues fifty-two days, during which they never taste food, till after sunset. The chief amusement on the holidays after lent, with the lower classes, very much resembles the English game of *bandy*.

Feast of Epiphany.

On the feast of Epiphany, which, according to the Abyssinians, is the 11th of January, they assemble, in commemoration of our Saviour's baptism, near brooks, into which they jump, after having received the blessing of the priest, leaping, dancing, ducking one another, and shouting. In the performance of baptism, three priests are engaged; one with the incense, another with a golden cross, and the third with the consecrated oil from the patriarch of Alexandria. The person to be baptized is first washed over with water, and afterwards crossed on the forehead with some of that element, over which the incense has been waved, and into which the consecrated oil has been dropped. When the person is a Mahometan, every joint and limb is crossed with the consecrated oil; he is then wrapped in a white linen cloth, and partakes of the sacrament. No unbaptized person is allowed to enter a church. The sacrament is given in both kinds, with new leavened bread, and wine made of a red grape common in some parts of the country. Great numbers of pilgrims, in a yellow dress, with cords round their waists, resort to the rich and beautiful plains of Walassè, where they spend their time, by no means innocently, amidst its retired groves.

Baptism.

Pilgrims.

Superstitions.

The Christians near Dixan are distinguished by a cross on their breast, arm, &c. and a blue silk string round their neck. They say prayers over whatever they eat, drink, receive, or give, and afterwards blow on it, turning their heads to the east. They turn the heads of animals to the west when they kill them. A striking resemblance may be traced between some of the superstitions of the Abyssinians, and those which still linger in our own country. The falcon, called *goodie-goodie*, already noticed, is never killed by them; and when an Abyssinian sets out on a journey and meets one, he watches it carefully; if it sit still, with its breast towards him, till he is past, he regards it as a good omen; if its back is towards him, it is unpropitious; and if it fly away, no motive will induce him to proceed on his journey. It is a prevalent belief, that every worker in iron transforms himself, at night, into an hyena, and preys on human flesh; but if, while thus transformed, he is wounded, the wound remains in the corresponding part of his own body.

Languages.

The languages spoken in Abyssinia and the neighbouring districts, are a corruption of the Geez, called Tigrè, Amharic, Falashan, Gafat, Agow, Tcheretch Agow, Shangalla, and Galla. According to Dr Murray, the written Geez is the oldest dialect of the Arabic in existence. The Amharic, the modern language of Abyssinia, is likewise an Arabic dialect, more simple than the Geez in the form of its verbs, but in all other respects the same. The Falasha is spoken by the tribes professing the Jewish religion, who formerly ruled in Dembea, Samen, and near the Angrab and Kahha; it is one of the ancient Ethiopian tongues, and has no affinity to the Arabic or Hebrew. The language of the Gafat nation is a corrupted dialect of the Amharic.

Intermixed and bordering tribes.

Respecting the tribes which border upon, or are intermixed with, the Abyssinians, Mr Salt has supplied us with some additional information.

Jews.

The Jews are very numerous in Gondar, and the provinces of Samen and Knara; they are chiefly employed in building and thatching houses.

Hazorta.

The Hazorta tribe inhabit the mountains near Tubbo, and command the only practicable passage into Abyssinia. They are a brave and rude people. Their population is about 5000, over whom there are five chiefs. They possess many cattle, which they seldom kill, but barter with the Abyssinians for grain, being almost entirely ignorant of the art of raising corn. They assist the Abyssinians in getting in their harvests. During the rainy season, they go to the sea-side for three, four, or five months, and on their return bring salt, which they exchange for grain with the Abyssinians. When they beat their *tom-toms*, they clap their hands, and hiss in such a manner, that the sound resembles the quick alternate pronunciation of the letters *p t s*. Only one person dances at a time, generally a chief; his feet move little, but his body, and particularly his shoulders, are extremely agitated with a kind of writhing gesture.

Shangalla.

The name Shangalla (or, according to Bruce, Shankala,) is applied by the Abyssinians to the whole race of negroes. One tribe of them were represented to Mr Salt as living three days' journey beyond the Nile, and as having a very imperfect notion of any supreme being. The only species of adoration which they exhibit occurs during a great holiday, when all the people assemble and kill a cow, by stabbing it in a thousand places. They have no priests or rulers, but pay respect to old age; the old men being allowed to drink first, and take two wives. In their marriages they mutually take each other's sisters. If one of the parties has no sister, he gives one of his female slaves. The women assist the men in ploughing, &c. and have an equal share of the produce of the land. These people are named from some circumstances relating to their birth, as "Born in the night;" or, "Born while making *booza*;" or from some marks on their bodies. They are buried in

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their clothes, without ceremony, the relatives feasting on the cattle of the deceased, his wife getting the household furniture, and the sons his arms, land, and agricultural implements. When hunting, they eat whatever they can procure, even an elephant or a rat. They tie the legs of their prisoners, and employ them in making cloth, or manufacturing iron. Those who cannot work, they kill. The Abyssinians consider it as sport to hunt the Shangalla.

Galla.

There are at least twenty tribes of the Galla, some of whom, entering Abyssinia from the south, have become naturalized, and adopted the manners of the Abyssinians. The tribes out of Abyssinia have little connection with one another, though they speak the same language; each has its own chief, and they are often engaged in mutual hostilities. There are two divisions larger than the rest, one of which, near the Abiad, or White River, retains its natural ferocity: they drink warm blood, adorn themselves with the entrails of animals, and ride on oxen. The Assubee Galla wear garments like the Abyssinians; grease and powder their hair; and cover their arms with bracelets, and with trophies, according to the number of the enemies slain.

Inhabitants of Hamazen.

The inhabitants of Hamazen differ from the rest of the Abyssinians, being darker and stronger limbed, and more like the Fungè, who live near Sennaar; they fight desperately with two-edged swords. In the province of Wojjerat, also, the men are larger and stouter than the other Abyssinians. They are said to be the descendants of Portuguese soldiers. Their fidelity to their rulers is proverbial. The plain, eight hours' distance from Wojjerat, is inhabited by the

Doba.

Doba, one of the isolated tribes of negroes found in all parts of Africa. They are mentioned by Alvarez, as, in his time, not marrying till they could make oath that they had put to death twelve Christians.

Agows.

The Agows, who were worshippers of the Nile till the seventeenth century, always fix their residence near the great branches of that river, for whose waters they still retain a veneration so great, that they will supply a stranger with milk, but not with water. Their buildings are without mortar. The houses of the higher ranks are in the form of Egyptian temples. At the earliest dawn of day they assemble before the doors of their chiefs, and chaunt their prayers.

Manufactures and commerce of Abyssinia.

It has already been mentioned, that one of the objects of Mr Salt's journeys was to ascertain, whether Abyssinia was likely to afford any new openings to British commerce. How far this is likely, will best appear from a sketch of the manufactures and commerce of that country. The former are few and contemptible: though cotton grows in many parts, and is of a superior quality, yet they import a considerable quantity from India, which they manufacture into a coarse cloth. As they have no dark blue colour, they unravel the threads of the blue cloth of Surat, and weave them again into their own webs: they procure a black dye from an earth, and red, yellow, and light blue from vegetables. Fine cloth is manufactured at Gondar, and coarse at Adowa; the latter, besides its common use, circulates as money: a coarse piece, sixteen cubits long, and one-three-fourths wide, is equal to thirty pieces of salt or one dollar; a piece, not so coarse, fifty cubits long, sufficient to make a dress for a chief, is equal to twelve dollars. Coarse carpets from sheep's wool, and the hair of goats dyed red, and light blue, are manufactured at Gondar and in Samen. In some parts the sheep skins are tanned, and worn by the women round their waists, or over their shoulders, whenever they stir out. At Axum, skins are made into parchment and finished well. Manufactures of iron and brass are common; the former is procured from Sennaar, Walkayt, and Barbera; knives are made at Adowa; and spears at Antalo: highly finished chains of brass are made by the Galla. There are many fairs and weekly markets. At a weekly market near Abha, were exposed for sale, iron, wrought and unwrought, for ploughshares, &c. cattle, horses, skins, cotton, ghee, butter in round balls and very white, &c. It is not infamous, as Mr Bruce asserts, for men to attend the markets.

Through Adowa, there are imported for Gondar and the interior of Abyssinia, lead, block-tin, gold-foil, Persian carpets, raw silks from China, velvets, French broad cloths, coloured skins from Egypt, and glass beads and decanters from Venice. Ivory, gold, and slaves, are the principal exports through Adowa to the coast. A few slaves from Abyssinia reach Cairo, by way of Cossir and Suez; they are esteemed more beautiful than those of Soudan.

Probability of its opening new channels to British commerce examined.

In estimating the probability, that Abyssinia may afford a new opening for British commerce, there are two circumstances which require particular consideration. There can be no doubt, that, in so far as a more accurate knowledge of the navigation of the Red Sea, and convenient places for landing the goods are requisite for this object, the journies of Lord Valentia and Mr Salt have been of great utility; but, there can be no communication with Gondar and the interior of Abyssinia, unless we could either form an alliance with the chief who commands there,—in which case we should be exposed to the enmity of the Ras of Tigrè, and thus be prevented even from advancing to a short distance from the coast,—or assist the Ras to liberate his sovereign, and replace him on his throne. Direct assistance could not be given, and the result seems very doubtful, were we only to furnish the Ras with a supply of arms. In the second place, supposing the communication with Gondar to be open and easy, Abyssinia at present can furnish nothing in exchange for our goods. We could indeed supply them, either from Britain, or from our Indian possessions, with most of the articles which they procure from Arabia; especially with India goods and raw cotton from India, for which, as cotton is used for clothing in the greatest part of Africa, there must be a great demand: besides, our goods could be sold cheaper, being exempt from the heavy duty imposed on what they now import. But for exchange with us, Abyssinia produces only ivory and gold: the latter in small quantities; the former we can procure cheaper elsewhere.

On the whole, therefore, when we consider, that the communication with the interior will probably always be liable to interruption; and that, even if the case were otherwise, no returns could be looked for, except from the increased industry and skill of the Abyssinians, or from regions with which the intercourse is slow and precarious,

there seems but little reason to expect that this country will afford any new openings to British commerce. (c.)

ACADEMY. An enumeration has been already given in the body of the work of most of those associations for the cultivation and improvement of science, learning, and art, which are known under the name of Academies; but as some of them have been omitted in that sketch, and others have been founded since it was written, we shall here endeavour, in as far as our information extends, to supply these defects. We shall also subjoin, in an additional article, an account of those Royal Academies whose object is the education of young men for the navy and army of Britain.

Geographical Academy of Lisbon.

I. In the year 1799 a *Geographical Academy* was established at Lisbon, principally for the purpose of elucidating the geography of Portugal. By the labours of the members of this academy, an accurate map of this country (which was much wanted) has been completed.

Royal Academy of Sciences at Lisbon.

II. *Academies of Science.* The present Queen of Portugal, at the beginning of her reign, established, at Lisbon, a Royal Academy of the Sciences, agriculture, arts, commerce, and economy in general. It is divided into three classes, natural science, mathematics, and national literature. It is composed of honorary members,—as ministers of state, and persons of high rank in Lisbon,—foreign members,—*socios veteranos*, and acting members. The total number is sixty, of which twenty-four belong to the last class. They enjoy an allowance from government, which has enabled them to establish an observatory, a museum, a library, and a printing-office. Their published transactions consist of *Memorias de Litteratura Portugueza;* and *Memorias Economicos;* besides *Scientific Transactions.* They have also published *Collecçao de Livros ineditos de Historia Portugueza.*

Royal Neapolitan Academy. Royal Academy at Turin.

The Royal Neapolitan Academy was established in 1779; the published *Memoirs* contain some valuable researches on mathematical subjects. The Royal Academy of Turin was established by the late King when Duke of Savoy. Its memoirs were originally published in Latin, under the title of *Miscellanea Philosophica Mathematica Societatis privatæ Taurinensis.* The first volume appeared in 1759. They are now published in French. Among the original members of this institution the most celebrated was La Grange, who burst on the scientific world quite unexpectedly, by the novelty and profoundness of his papers in the first volume of the Transactions.

Padua.

An Academy of Sciences, Belles-lettres, and Arts, was established at Padua, by the senate, near the close of the eighteenth century. It is composed of twenty-four pensionaries, twelve free associates, twenty-four pupils, sixteen associates belonging to the Venetian states, and twenty-four foreigners, besides honorary members. It has published a few volumes of Transactions in the Italian language.

Genoa.

The Academy of Sciences and Belles-lettres of Genoa was established in 1783. It consists of thirty-two members; but their labours have been chiefly directed to poetry, nor are we aware that they have published any memoirs.

Milan.

The academy of Milan was preceded, and perhaps introduced, by a literary assembly consisting of ten persons, who published a sheet weekly, containing short remarks on subjects of science, belles-lettres, and criticism. This society terminated in 1767. Soon afterwards another was established, who publish their Transactions, under the title of *Scolta d'Opuscoli Scientifici*, which contain several very interesting papers.

Sienna.

The Academy of Sciences at Sienna, which was instituted in 1691, published the first volume of their transactions, in 1761, and have continued them since, at long intervals, under the title of *Atti dell' Academia di Siena.*

Verona.

Between the year 1770 and 1780, M. Lorgna established at Verona an academy of sciences, of a novel description. The object of it was to form an association among the principal scientific men in all parts of Italy, for the purpose of publishing their memoirs. The first volume appeared in the year 1782, under the title of *Memorie di Matematica e Fisica della Societa Italiana.* The most celebrated names that appear in this volume are those of Boscovich, the two Fontanas, and Spallanzani. There are also scientific academies at Mantua, Pisa, and Pavia, but the two last do not publish their Transactions.

Changes in the Academy of Berlin.

In the Royal Academy of Sciences at Berlin some changes have lately been made, which it may be proper to mention. The object of these changes was to direct the attention of the members to researches of real utility, to improve the arts, to excite national industry, and to purify the different systems of literary and moral education. To attain these ends, a directory was chosen, consisting of a president, the four directors of the classes, and two men of business, not members of the academy, though at the same time men of learning. To this directory was entrusted the management of the funds, and the conducting the economical affairs of the institution. The power of choosing members was granted to the academy, but the King was to have the privilege of confirming or annulling their choice. The public library at Berlin, and the collection of natural curiosities, was united to the academy, and entrusted to its superintendence.

Academy of Sciences at Manheim.

The Academy of Sciences at Manheim was established by Charles Theodore, Elector Palatine, in the year 1755. The plan of this institution was furnished by Schæpflin, according to which it was divided into two classes, the historical and physical. In 1780 a subdivision of the latter took place, into the physical, properly so called, and the meteorological. The meteorological observations are published separately, under the title of *Ephemerides Societatis Meteorologicæ Palatinæ.* The historical and physical memoirs are published under the title of *Acta Academia Theodoro Palatinæ.*

Bavarian Academy.

The Electoral Bavarian Academy of Sciences at Munich was established in 1759, and publishes its memoirs under the title of *Abhandlungen der Baierischen Akademie.* Soon after the Elector of Bavaria was raised to the rank of King, the Bavarian government, by his orders, directed its attention to a new organization of the academy of sciences of Munich. The design of the King was to render its labours more extensive than those of any similar institution in Europe, by giving to it, under the direction of the ministry, the immediate superintendence over all the establishments for

Academy. public instruction in the kingdom of Bavaria. The Privy-Councillor Jacobi, a man of most excellent character, and of considerable scientific attainments, was appointed president. The Electoral Academy at Erfurt was established by the Elector of Mentz, in the year 1754. It consists of a protector, president, director, assessors, adjuncts, and associates. Its object is to promote the useful sciences. Their memoirs were originally published in the Latin language, but afterwards in German. The Hessian Academy of Sciences at Giessen publish their transactions under the title of *Acta Philosophico-Medica Academiæ Scientiarum Principalis Hessiacæ*. In the Netherlands there are scientific academies at Flushing and Brussels, both of which have published their Transactions.

Erfurt.

Hessian.

Academies of the Fine Arts: Turin.

III. *Academies of the Fine Arts*. In 1778, an academy of painting and sculpture was established at Turin. Their meetings were held in the palace of the king, who distributed prizes among the most successful members. In Milan an Academy of Architecture was established so early as the year 1380, by Galeas Visconti. About the middle of the last century, an Academy of the Arts was established there, after the example of those at Paris and Rome. The pupils were furnished with originals and models, and prizes were distributed annually. The prize for painting was a gold medal, and no prize was bestowed till all the competing pieces had been subjected to the examination and criticism of competent judges. Before the effects of the French revolution reached Italy, this was one of the best establishments of the kind in that kingdom. In the hall of the academy were some admirable pieces of Correggio, as well as several ancient paintings and statues of great merit; particularly a small bust of Vitellius, and a statue of Agrippina, of most exquisite beauty, though it wants the head and arms. The Academy of the Arts, which had been long established at Florence, but which had fallen into decay, was restored by the late Grand Duke. In it there are halls for nudities and for plaster figures, for the sculptor and painter. The hall for plaster figures had models of all the finest statues in Italy, arranged in two lines; but the treasures of this, as well as all the other institutions for the fine arts, have been greatly diminished by the rapacity of the French. In the saloon of the Academy of the Arts at Modena, there are many casts of antique statues; but since it was plundered by the French it has dwindled into a petty school for drawings from living models: it contains the skull of Correggio. There is also an academy of the fine arts in Mantua, and another at Venice.

Milan.

Florence.

Modena, &c.

Madrid.

In Madrid, an Academy for Painting, Sculpture, and Architecture, was founded by Philip V. The minister for foreign affairs is president. Prizes are distributed every three years. In Cadiz a few students are supplied by government with the means of drawing and modelling from figures; such as are not able to purchase the requisite instruments are provided with them.

Stockholm.

An Academy of the Fine Arts was founded at Stockholm in the year 1733 by Count Tessin. In its hall are the ancient figures of plaster presented by Louis XIV. to Charles XI. The works of the students are publicly exhibited, and prizes are distributed annually. Such of them as display distinguished talents obtain pensions from government, to enable them to reside in Italy for some years, for the purposes of investigation and improvement. In this academy there are nine professors, and generally about four hundred students. In the year 1705 an Academy of Painting, Sculpture, and Architecture was established at Vienna, with the view of encouraging and promoting the fine arts.

Academy.

Vienna.

Academies of History: Madrid.

IV. *Academies of History*. About the year 1730, a few individuals in Madrid agreed to assemble at stated periods, for the purpose of preserving and illustrating the historical monuments of Spain. In the year 1738, the rules which they had drawn up, were confirmed by a royal cedula of Philip V. This academy consists of twenty-four members. The device, a river at its source; the motto, *In patriam populumque fluit*. It has published editions of *Mariana*, *Sepulveda*, *Solis*, and the ancient *Chronicles* relative to the affairs of Castile, several of which were never before printed. All the diplomas, charters, &c. belonging to the principal cities in Spain, since the earliest period, are in its possession. It has long been employed in preparing a geographical dictionary of that country.

Academies of Antiquities: Herculaneum.

V. *Academies of Antiquities*. Under this class the Academy of Herculaneum properly ranks. It was established at Naples about 1755, at which period a museum was formed of the antiquities found at Herculaneum, Pompeia, and other places, by the Marquis Tanucci, who was then minister of state. Its object was to explain the paintings, &c. which were discovered at those places; and for this purpose the members met every fortnight, and at each meeting three paintings were submitted to three academicians, who made their report on them at their next sitting. The first volume of their labours appeared in 1775, and they have been continued under the title of *Antichita di Ercolano*. They contain engravings of the principal paintings, statues, bronzes, marble figures, medals, utensils, &c., with explanations. In the year 1807, an Academy of History and Antiquities, on a new plan, was established at Naples, by Joseph Bonaparte. The number of members was limited to forty; twenty of whom were to be appointed by the king, and those twenty were to present to him, for his choice, three names for each of those wanted to complete the full number. Eight thousand ducats was to be annually allotted for the current expences, and two thousand for prizes to the authors of four works, which should be deemed by the academy most deserving of such a reward. A grand meeting was to be held every year, when the prizes were to be distributed, and analyses of the works read. The first meeting took place on the 25th April 1807; but the subsequent changes in the political state of Naples have prevented the full and permanent establishment of this institution. In the same year an academy was established at Florence, for the illustration of Tuscan antiquities, which has published some volumes of memoirs.

Naples.

Florence.

Celtic Academy at Paris.

In consequence of the attention of several literary men in Paris having been directed to Celtic antiquities,

a Celtic Academy was established in that city in the year 1807. Its objects were, 1st, the elucidation of the history, customs, antiquities, manners, and monuments of the Celts, particularly in France; 2d, the etymology of all the European languages, by the aid of the Celto-Briton, Welsh, and Erse; and, 3d, researches relating to Druidism. The attention of the members was also particularly called to the history and settlements of the Galatæ in Asia. Lenoir, the keeper of the museum of French monuments, was appointed president. A fasciculus, consisting of one hundred and fifty or one hundred and sixty pages, was to be published monthly; the engravings, illustrative of Celtic antiquities, were to be under the inspection of Lenoir. The devices are, *Gloriæ majorum;* and *Sermonem patrium, moresque requiret.*

VI. *Academies of Languages.* The Royal Swedish Academy was founded in the year 1786, for the purpose of purifying and perfecting the Swedish language. A medal is struck by its direction every year, in honour of some illustrious Swede. This academy do not publish their Transactions. An Academy of the Russian language is attached to the Imperial Academy of Sciences at Petersburgh. (c.)

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The following is a catalogue of the published Memoirs and Transactions of the principal *Academies* of science and literature in Europe.

*Denmark.*

Skrifter som udi det Kiobenhavnske Selskab ere Fremladge. 12 vol. 4to. Copenh. 1745-1779.

Nye Samling, 1781-1808.

Scripta Societatis Hafniensis. 3 vol. 1745-47.

Acta Literaria Societat. Haf. 1778. Copenh.

*France.*

Mémoires de l'Académie Celtique. Paris. 1807. 5 vol. 8vo.

Mémoires de l'Académie de Dijon. 1769-1772. 2 vol. 8vo.

Nouveaux Mémoires. 1782-1785. 7 vol.

Histoire et Mémoires de l'Académie Royale des Sciences, depuis son Etablissement, en 1666, jusqu' 1790. 108 vol. 4to.

Table des Matières contenues dans l'Hist. et Mém. de l'Acad. Par M. Godin. 1666-1730. 4 vol. 4to.

Table depuis l'année 1731 jusqu'à l'an 1780, inclusivement. Par M. Demours. 5 vol. 4to.

Nouv. Tables des Articles contenues dans les Vol. de l'Acad. depuis 1666 jusqu'en 1770. Par M. l'Abbé Rozier. 4 vol. 4to.

Recueil des Piéces qui ont remportés les Prix fondez dans l'Acad. des Scien. 9 vol. 4to.

Machines et Inventions approuvées par l'Acad.—Dessignées et publiées par M. Gallon. 7 vols. 4to.

Mémoires de Mathematique et de Physique, presentés à l'Acad. par les Sçavans Etrangers. 11 vol. 4to.

Histoire et Mémoires de l'Academie des Inscriptions et Belles Lettres. Paris. 1701-1793. 50 vol. 4to.

Tableau des Ouvrages contenus dans ce Recueil. Paris. 1791. 4to.

Hist et Mém. de l'Acad. des Sciences et Belles Lettres de Toulouse. 1781-89. 4 vol. 4to.

*Germany.*

Ephemer. et Act. Academiæ Cæsareæ Naturæ Curiosorum. Nuremb. 1670-1791. 47 vol. 4to.

Kellneri Index Rerum Memorab. in Acad. Nat. Curios. Nuremb. 1739.

Büchneri Historia Acad. Naturæ Curiosorum. Hal. 1756.

Abhandlungen der Kaiserlichen Academie. 1755. Nuremb. 4to.

Acta Philosophico-Medica Academ. Scientiarum Principalis Nassiacæ. 4to. Giessæ. 1771.

Acta Academ. Electoralis Moguntinæ Scientiarum Utilium. Erford. 1751-1795.

Nova Acta. 1796-1806.

Historia et Commentationes Acad. Scientarum et Elegantiarum Literarum Theodoro-Palatinæ. Manh. 5 vol. 4to.

Abhandlungen der Baierischen Academie. 1763-1776. 10 vol. 4to.

Neue Abhandlungen. 1778-1797. 7 vol. 4to. Munich.

*Ireland.*

Transactions of the Royal Irish Academy. 1787-1810. 11 vol. 4to.

*Italy.*

Commentarii de Bononiensi Scient. et Artium Instituto atque Academia. Bonon. 1731-1791. 7 vol. 4to.

Saggi di Naturale Esperienze fatte nell' Academie del Cimento. Flor. 1667-1691.

Atti e Memorie Inedite dell' Academ. del Cimento, publicate da Targione Tozzati. Flor. 1780. 4 vol. 4to.

Tentamina Academ. del Cimento Edit. à Musschenbroek. Lug. Bat. 1731.

Experiments of the Academy of Cimento, translated by Waller. Lond. 1684. 4to.

Saggi di Dissertatione Accademiche lett. nell' Academ. di Cortona. Rom. 1735-1791. 10 vol. 4to.

Saggi Scientifici e Literari dell' Academia di Padova. 1786-1794. 4 vol. 4to.

Gli Atti dell' Academia delle Scienze di Siena, detta de Fisiocritici. 1761-1781. 6 vol. 4to.

Mémoires de l'Acad. des Sciences de Turin. 1784-1811. 14 vol. 4to.

*Naples.*

Atti della Realo Accademie delle Scienze e Belle-Lettere di Napoli. 4to. Nap. 1788.

*Netherlands.*

Mémoires de l'Académie des Sciences et Belles Lettres de Bruxelles. 1777-1788. 5 vol. 4to.

*Prussia.*

Histoire et Mémoires de l'Académie Royale des Sciences et Belles Lettres de Berlin. 1746-1771. 25 vol. 4to.

Nouveaux Mémoires. 1770-1787. 16 vol. 4to.

Mémoires depuis 1787 jusqu'à l'an 1804. 14 vol. 4to.

Histoire de l'Acad. de Berlin, depuis son Origine jusqu'à present. 1752. 4to. Berlin.

*Portugal.*

Memorias da Academia Real das Sciencias de Lisboa. 1797.

——— de Economica. 1789-1791. 3 vol. 4to.

——— de Agricultura. 1787-1790. 2 vol. 4to.

——— de Litteratura Portugueza. 1792-96. 6 vol.

Academy.

*Russia.*

Academiæ Scientiarum Petropolitanæ Commentarii et Acta. 1726-1811. 65 vol. 4to.

*Spain.*

Memorias de la Real Acad. de la Historia. Madrid. 1796-1805. 4 vols. 4to.

*Sweden.*

Akademiens Konungl. Svenska. Vetenskaps Handlingar. 1739-1779. 40 vol. 8vo. Stockh.

Nya Handlingar. 1780-1811. 32 vol. 8vo.

*A German translation* by Kästner and others, was published at Hamburgh, in 40 vol. 8vo. entitled, Abhandlungen der Koniglichen Schwedischen Akademie.

We shall introduce a similar catalogue of the Transactions of those kindred associations, known under the name of *Societies*, when we come to give the necessary additions to that article. For an account of the Institute of France, see INSTITUTE in this Supplement.

Academies for military and naval Instruction.

ACADEMY is also a term applied to those royal collegiate seminaries in which young men are educated for the navy and army. In this country there are three seminaries of this description: The Naval Academy at Portsmouth; the Royal Military Academy at Woolwich; and the Royal Military College at Farnham and Sandhurst.

Naval Academy at Portsmouth.

I. *The Naval Academy at Portsmouth* was founded by George I. in 1722; but the official warrant for its establishment does not appear to have been issued till the 21st of February 1729. This warrant bears, that the academy was instituted for the education of forty young gentlemen, fifteen of whom were to be sons of commissioned officers in the navy. The commissioner of the navy at Portsmouth was, *ex officio*, to be governor; and there were to be two masters for the instruction of the students in navigation and the sciences introductory or auxiliary to it, besides a master for writing and drawing. The annual expence was about L. 1169.

In the year 1773, his present Majesty, during a visit he paid to Portsmouth, suggested the extension and improvement of the Naval Academy; but no steps were taken towards this object till the year 1806, when an order in council was issued for a new and enlarged establishment. By this order it was henceforward to be called the *Royal Naval College at Dock-yard, Portsmouth*, and the following officers were appointed: 1st, a Governor, who was to be the First Lord of the Admiralty for the time being; and, 2d, a Lieutenant-Governor and inspector, who was to be a post-captain in the navy. As the course of education which the students were to follow necessarily embraced the mathematical sciences, the order directed that the University of Cambridge should recommend three of its graduates, who were able mathematicians; one of whom the First Lord of the Admiralty, as governor, was to nominate Professor. In order to incite him to the regular and faithful discharge of his duty, he was to receive no fixed salary, but to be paid L. 8 annually by each student attending the Academy. The next in rank and authority under the professor is the preceptor, or head master, who must be a graduate of one of the universities; he has the control of the students at all hours, and is to instruct them in the classics, moral philosophy, geography, history, and general literature.

Academy.

The order in council also appointed a writing-master, who, besides giving instructions in his own immediate line, was to prepare the students for the lectures of the professor, by teaching them arithmetic, fractions, algebra, and geometry. There are, besides, masters for drawing, French, dancing, and fencing. The surgeon of the dock-yard gives his professional advice and assistance. The domestic economy of the establishment is entrusted, by the order in council, to a disabled and meritorious half-pay lieutenant.

The peculiar advantages of this academy, however, consist in the practical knowledge which it is intended and calculated to bestow on those who are admitted. For this purpose, the master attendant of the dock-yard gives weekly lessons on the management of ships afloat, in one of the cruizing sloops; and likewise lessons in rigging, and preparing ships for sea, on board such vessels as are preparing to sail from Portsmouth harbour. Forty seven lessons are given in each of these branches annually, five weeks being allowed for holidays.

The master shipwright of the dock-yard instructs the students in the principles on which ships of war are built; and in the mode of putting the several parts together—making masts, and all other branches of naval architecture, by attending them one day in the week, during the six summer months, through the dock-yards. The gunner of marine artillery also instructs them in the practical knowledge of gunnery, and in the use of the firelock.

The number of scholars, by the order in council of February 1806, was increased from forty to seventy: of these, thirty might be indiscriminately sons of officers, noblemen, or gentlemen; but forty were invariably to be sons of commissioned officers in the naval service. None are admitted under thirteen, nor above sixteen years of age: those are preferred to fill vacancies who have been previously at sea, provided they are of the proper age. No student can remain at the academy longer than three years; and the whole period of his residence is to be reckoned as two of the six years, which it is necessary for a midshipman to serve, before he can obtain a lieutenant's commission. Each student, while actually at the academy, that is, during three hundred and thirty days in the year, receives four shillings daily; out of which he pays L. 8 annually to the professor. The annual expence of the establishment, as fixed by the order in council of 1806, is about L. 6363.

In order to secure to the country the services of the students in that line, for which they have been educated, the parents of all of them, except such as have been previously at sea, grant a bond of L. 200, which is forfeited, in case they do not enter into the naval service. The first year they are at sea, they are rated as volunteers, on *able seaman's* pay; the second year, they have the rank and pay of midshipmen. They are directed to keep journals; to draw head-lands, &c.; and when the ship comes into port, they are to attend the professor, who is to im-

Academy. spect their journals, and examine them regarding their advancement in the theoretical and practical knowledge of this profession.

This academy, as established by the order in council already mentioned, was confined entirely to the education of young *cadets* for the navy: but in the third report of the commissioners, appointed to inquire into the civil affairs of the navy, laid before Parliament in June 1806, a regular system of education for *shipwrights* was also proposed; and the suggestion was accordingly carried into effect, though not till some years afterwards. The professor of the naval academy is also the instructor of the shipwright apprentices, but his instructions extend only to that class who are to serve on board his Majesty's ships of war. No apprentice can be admitted to the academy under sixteen years of age; and he must be previously examined by the professor, before a committee of the navy board, in arithmetic, the first six books of Euclid, and in French. If the candidate is approved, he must be bound to the resident commissioner of the dock-yard, for seven years, six of which he spends at the academy, and one at sea. The salary of the apprentices increases yearly, from L. 60, to L. 140; out of which they pay L. 8 to the professor. The number of these apprentices was originally limited to twenty-five; but latterly, six more have been added. They spend half the day under the professor; and the other half under the master shipwright, in the mould lofts, learning the management of timber, and manual labour in ship building. Lectures are delivered three times a week, after working hours, on the branches of science connected with naval architecture; and annual examinations take place before the resident commissioner, the master shipwright, and the professor.

Out of the class of shipwright apprentices, thus educated, are selected the master measurers; foremen of shipwrights; master boat-builders; master mast-makers; assistants to master ship-builders; mechanists in office of inspector-general of naval works; assistants to surveyors of the navy; master shipwrights; second surveyor of navy; inspector-general of navy works; and first surveyor of navy.

Military Academy at Woolwich.

II. *The Royal Military Academy at Woolwich* was established by George II. by warrants dated 30th of April and 18th of November 1741; for the purpose of instructing "raw and inexperienced people, belonging to the military branch of the ordnance, in the several parts of the mathematics necessary for the service of the artillery, and the business of engineers." We find no further notice respecting this institution till the year 1776, when the number of scholars, then called *cadets,* amounted to forty-eight. In the year 1786, they were increased to sixty; in 1796, to ninety; and in 1798, to one hundred, forty of whom were educated for the service of the East India Company. This number continued till the year 1806, when the establishment was improved and further extended; the number of masters being increased, and the cadets being divided into two bodies. This latter regulation took place in consequence principally of the unhealthy and confined situation of the old buildings in the royal arsenal; new buildings having been erected on Woolwich Common, on the side of Shooter's Hill, in a more open and dry situation. As soon as these were finished, one hundred and twenty-eight cadets were lodged in them; sixty continuing in the royal arsenal. At this period there were nine masters of mathematics. In 1810, the cadets for the service of the East India Company were withdrawn from Woolwich; and the extra cadets, who, for want of room, had been sent to Marlow, or to private schools, were taken into the college, under the name of supernumeraries. The establishment at present consists of two hundred cadets, one hundred and twenty-eight of whom are in the new buildings, and seventy-two, including twelve supernumeraries, reside in the arsenal. The number of cadets is not fixed by warrant, but is at the discretion of the master-general of ordnance, who, with the board of ordnance, have the entire superintendence of the institution. The immediate direction, however, is vested in the lieutenant-governor and inspector, who are chosen generally from the artillery or engineers by the master-general of the ordnance. It is the duty of these officers, aided by the assistant-inspector, to control the masters and professors, and to see that the cadets are taught the necessary branches of instruction. The professors and masters are appointed on the recommendation of the lieutenant-governor, who, assisted by men of science, previously examines them. One master is appointed for every sixteen cadets. At present there are a professor of fortification, with two assistants; a professor of mathematics, with six masters and assistants; two French masters; a drawing-master for ground, and an assistant; a drawing-master for figures; and another for landscape; a dancing-master; a fencing-master; two modellers; and a lecturer on chemistry. Lectures are also given on the different branches of natural philosophy. The inferior branches of education are taught at the lower institution in the arsenal, and the higher branches at the buildings on the common.

The young men educated at the Royal Military Academy of Woolwich are the sons of noblemen, gentlemen, or military officers. They are called gentlemen cadets, and cannot be admitted under fourteen, nor above sixteen years of age. They are nominated by the master-general of the ordnance, as governor of the academy; but they must be well grounded in English grammar, arithmetic, and French, and they undergo a previous public examination before the masters of the academy. The cadets educated at Woolwich are considered as the first company of the royal regiment of artillery, of which the master-general of the ordnance is the captain. They are also divided into companies; each company having a captain and two subalterns, as military directors. Each cadet receives 2s. 6d. a-day, or L. 45, 12s. 6d. a-year, which covers all his regular expences, except keeping up his linen. The annual vacations consist of twelve weeks.

Monthly returns of the studies of the cadets, shewing the relative progress of each in every branch, with his particular character subjoined, are sent to the master-general of the ordnance; there are also public examinations before the general-officers of the

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ordnance corps. Commissions are given to the cadets according to the report of their merits and acquirements: they have their choice of entering either into the artillery or engineers. The whole expence to Government of the Royal Military Academy at Woolwich is at the rate of about L. 100 for each cadet.

Royal Military College.

III. *The Royal Military College*, which is at present established at Farnham, in Surrey, and at Sandhurst, near Bagshot, was originally settled at High Wycombe and Great Marlow. The establishment at High Wycombe commenced in January 1799, at which time there was a superintendent, commandant, two or three professors, and thirty-four students. Next year four more professors were added; and in 1801 it took the name of the *Royal Military College* by his Majesty's warrant. A supreme board of Commissioners, to superintend and regulate its concerns, was appointed, consisting of the Commander-in-chief, Secretary of war, and the heads of the great military departments, with others of high rank in the army; three of whom, including the Secretary at war, and the Adjutant or Quartermaster-general, were to form a board of management. By his Majesty's warrant, dated 4th of June 1802, another department, called the *Junior Department* of the Royal Military College, was formed; and the objects of this, as well as of the original, or *Senior Department*, were specifically pointed out. A collegiate board was also established, for the internal government of the college, consisting of the governor, lieutenant-governor, and the commandants of the two departments. The last warrant relating to this establishment is dated 27th May 1808: this places both the departments, forming one college, under the command of the governor and lieutenant-governor; it continues the collegiate board, and vests the appointment of professors and masters, after public notice of vacancies, and the examination of the candidates in the presence of the collegiate board, in the supreme board.

By these warrants, it was declared that the *Junior Department* of the Institution, which was then at Marlow, was principally intended for those who were destined for the military profession, in order to ground them in the necessary sciences by the time they could hold commissions, and also to afford provision for the orphan sons of meritorious officers, who had fallen or been disabled in the service of their country, or whose pecuniary circumstances rendered them unable to educate their sons properly for a military life. The warrant of 1808 fixed the number of students in the *Junior Department* at four hundred and twelve, divided into four companies of an hundred and three cadets each. They are admitted upon three different establishments:—1. Orphan sons of officers of the army or navy, who have fallen, died, or been disabled in the service. They are admitted free of expence, except that they are to bring the first suit of uniform on their admission, and to keep up their stock of linen, during their residence at the college. 2. The sons of officers actually serving in the army or navy, who pay a certain sum annually, (from L. 10 to L. 60,) according to the rank of their fathers. 3. The sons of noblemen and gentlemen, who pay L. 100 *per annum* each.

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The military branch of the establishment attached to the *Junior Department*, consists of a commandant, a major, three captains, an adjutant, and inferior officers.

The studies pursued in this department are mathematics, natural philosophy, history, geography, fortification, military-drawing, landscape-drawing, arithmetic, classics, French, German, fencing, and writing. There are seven masters of mathematics, four of fortification, five of military-drawing, three of landscape-drawing, four of history, geography, and classics, six of French, one of German, and three of fencing. The course for this department lasts from three and a half to four years.

Applications for admission must be made to the Commander-in-chief, through the governor of the college, and his Majesty's approbation obtained. Every candidate, previous to admission into the Junior Department, must pass an examination in Latin and English grammar, and in the first four rules of arithmetic: no candidate can be admitted under thirteen or above fifteen years of age.

Examinations are held monthly, which are conducted by the professors of the Senior Department, for the purpose of ascertaining the progress of each cadet, previous to his removal from one class to another. There are also half-yearly examinations, in presence of the Collegiate Board, on which occasion, one or more members of the Supreme Board, not being members of the Collegiate Board, attend. These examinations are held previous to the cadet's receiving commissions from the college; and if they acquit themselves well, they are furnished by the Board of Commissioners, in whose presence the examination takes place, with certificates of qualification to serve in the army as officers. The third class, or gentlemen-cadets, are allowed to purchase commissions at any time during their continuance at the college; but no gentleman-cadet can be recommended for a commission by private interest, until he has made a certain progress in his studies.

The *Senior Department* of the Royal Military College, which was originally established at High Wycombe, is intended for the purpose of instructing officers in the scientific parts of their profession, with a view of enabling them better to discharge their duty, when acting in the command of regiments, and, at the same time, of qualifying them for being employed in the quarter-master and adjutant-general's department. The military branch of the establishment of the senior department, consists of a commandant and adjutant. The studies pursued are mathematics, in all the various branches, fortification, gunnery, castramentation, military-drawing, and surveying, the reconnoitring of ground, the disposition and movement of troops, under all the various circumstances of defensive and offensive war, rules for estimating the military resources of a country, and the German and French languages. There are six professors in this department,—one for mathematics, one for fortification, two for military-drawing, one for French, and one for German.

The full complement of the *Senior Department* consists of thirty students. No officer can be admit-

Academy ‖ Achromatic Glasses.

ted till he has completed the twenty-first year of his age, and actually served with his regiment, as a commissioned officer, three years abroad, or four years at home. Applications for admission must be made to the governor, through the commanding-officer of the regiment to which the candidate belongs, and the governor transmits the application to the commander-in-chief for his Majesty's approbation. Such examination as may be deemed requisite, is required previous to admission. Each student of this department pays into the funds of the college thirty guineas annually, and after a certain period he is obliged to keep a horse, for the purpose of receiving such instruction as is given in the field. There are public examinations half-yearly, conducted on the same principle as the half-yearly examinations of the Junior Department. Such officers as have gone through the regular course of studies, and have passed this examination with credit, receive certificates that they are duly qualified for staff-appointments, signed by the board who examined them, and sealed with the seal of the college.

Officers or students of the first department, non-commissioned officers, and other military persons belonging to the college, as well as the gentlemen cadets of the junior department, are subject to the articles of war, for which purpose, the latter are placed on the establishment of the army, and receive 2s. 6d. per day. This money contributes towards the expence of their education. The gentlemen cadets wear military uniforms.

The general staff of the college consists of the governor, the lieutenant-governor, the inspector-general of instruction, and the chaplain, who, besides performing divine service, teaches the evidences and principles of Christianity. The rest of the staff are exclusively occupied with the finances of the college.

In 1801, five hundred acres of land were purchased at Sandhurst near Bagshot; and on this space large and commodious buildings have been erected, into which the *Junior Department* has been recently removed from Great Marlow; the *Senior Department* remaining at Farnham, which is no great distance from Sandhurst.

The reader will find an account of some establishments for the education of those destined for the service of the East India Company, under the word HERTFORD, in this Supplement. (C.)

ACHROMATIC GLASSES. The theory and construction of achromatic glasses have been already treated at some length, and with considerable ability, under the article *Telescope*, in the Encyclopædia. A subject of such importance, however, seems to require a distinct and prominent place. We purpose, therefore, to review the whole again; and while we separate the exposition of principles from the complicated calculations that depend on them, we shall endeavour to spread more interest over the discussion, by tracing the successive steps in the progress of optical discovery.

Invention of the Telescope.

The invention of the telescope, by which the powers of vision are extended to the utmost boundaries of space, forms an epoch in the history of science. The human intellect had at last emerged from the long night of error, and begun to shine with unclouded lustre. The age of erudition, which arose on the revival of letters, had been succeeded by the age of science and philosophy. The study of the ancient classics had infused some portion of taste and vigour: But men did not long remain passive admirers; they began to feel their native strength, and hastened to exert it. A new impulsion was given to the whole frame of society; the bolder spirits, bursting from the trammels of authority, ventured to question inveterate opinions, and to explore, with a fearless yet discerning eye, the wide fields of human knowledge. Copernicus had partly restored the true system of the world; Stevinus had extended the principles of mechanics; the fine genius of Galileo had detected and applied the laws of motion; the bold excursive imagination of Kepler had, by the aid of immense labour, nearly completed his discovery of the great laws which control the revolutions of the heavenly bodies; and our countryman, Napier, had just rendered himself immortal by the sublime discovery of logarithms. At this eventful period, amidst the fermentation of talents, the refracting telescope was produced by an obscure glass-grinder in Holland,—a country then fresh from the struggle against foreign oppression, and become the busy seat of commerce and of the useful arts. Yet the very name of that meritorious person, and the details connected with his invention, are involved in much obscurity. On a question of such peculiar interest, we shall afterwards endeavour to throw some light, by comparing together such incidental notices as have been transmitted by contemporary writers. In the meantime, we may rest assured, that the construction of the telescope was not, as certain authors would insinuate, the mere offspring of chance, but was, like other scientific discoveries, the fruit of close and patient observation of facts, directed with skill, and incited by an ardent curiosity. A new, and perhaps incidental appearance, which would pass unheeded by the ordinary spectator, arrests the glance of genius, and sets all the powers of fancy to work. But the inventor of the telescope, we are informed, was acquainted besides with the elements of geometry, which enabled him to prosecute his views, and to combine the results with unerring success. No sooner was this fine discovery—admirable for the very simplicity of its principle—whispered abroad, than it fixed the attention of the chief mathematicians over Europe. Kepler, with his usual fertility of mind, produced a treatise on Dioptrics, in which he investigated at large the distinct effects of the combinations of different lenses. Galileo, from some very obscure hints, not only divined the composition of the telescope, but actually constructed one, with a concave eye-glass, which still bears his name. This telescope is shorter, but gives less light than another one proposed by Kepler, and called the astronomical telescope, which inverts the objects, and consists likewise of only two lenses, that next the eye being convex. With such an imperfect instrument—the same, indeed, though of rather higher magnifying power, with our modern opera-glass—did the Tuscan artist, as our great poet quaintly styles the philosopher, venture to explore

the heavens.* He noticed the solar spots; surveyed the cavernous and rocky surface of the moon; observed the successive phases of the planet Venus; and discovered the more conspicuous of Jupiter's satellites. The truths thus revealed shook the inveterate prejudices of the learned, and furnished the most triumphant evidence to the true theory of the universe.

It is painful to remark, that the application of the first telescope in the country which had given it birth, was directed to a very different purpose. The maker, after having finished one, judging it of singular use in the military profession, was naturally induced, by the hope of patronage, to present it to the younger Prince Maurice, whose bravery and conduct had so beneficially contributed to the independence of the United Provinces. But at this moment, a bloody tragedy was acting in Holland. The chief of the republic, not content with that high station which the gratitude of his fellow-citizens had conferred upon him, sought to aggrandize his power by crushing all opposition. In the prosecution of his ambitious designs, he artfully gained the favour of the undiscerning populace, and, joining his intrigues to the violence of the Presbyterian clergy, he succeeded in preferring the charge of a plot against the more strenuous supporters of the commonwealth, which involved them in ruin. Not only was the celebrated Grotius condemned to the gloom of perpetual imprisonment, but the aged senator Barneveld, whose wise and upright councils had guided the state amidst all the troubles of a long revolutionary storm, was led to the scaffold, on the 14th of May 1619, while his persecutor, ashamed to approach the spectacle of his sufferings, beheld at a distance, with the coolness of a tyrant, from the windows of his palace, and *by help of a telescope*, the gesture and aspect of the venerable patriot, and all the melancholy circumstances attending the decollation.

Improvers of the Telescope.

The skill and ingenuity of artists and mathematicians were now exerted in attempts to improve the construction of an instrument so fortunately contrived. The perfection of the telescope would require the union, as far as they are capable of being conjoined, of three different qualities,—distinctness of vision, depth of magnifying power, and extent of field. Of these requisites, the two first are evidently the most important, and to attain them was an object of persevering research. For the condition of amplitude and clearness, it was necessary that the principal image, or the one formed by the eye-glass, should be large, bright, and well defined. On the supposition then generally received, that, in the passage of light through the same media, the angle of incidence bears a constant ratio to the angle of refraction, which is very nearly true in the case of small angles, it followed, as a geometrical consequence, that the spherical figure would accurately collect all the rays into a focus. To obtain the desired improvement of the telescope, therefore, there seemed to want nothing but to enlarge sufficiently its aperture, or to employ for the eye-glass a more considerable segment of the sphere. On trial, however, the results appeared to be at variance with the hasty deductions of theory, and every sensible enlargement of aperture was found to occasion a corresponding glare and indistinctness of vision. But a discovery made soon afterwards in optics led to more accurate conclusions.

Snell.

Willebrord Snell, a very ingenious Dutch mathematician, who was snatched away at an early age, traced out by experiment, about the year 1629, the true law that connects the angles of incidence and of refraction, which the famous Descartes, who had about this time chosen Holland for his place of residence, published, in 1637, in his Dioptrics, under its simplest form, establishing, that the sines of those angles, and not the angles themselves, bore a constant ratio in the transit of light between the same diaphanous media. It hence followed, that the lateral rays of light which enter a denser medium, bounded by a spherical surface, in the direction of the axis, will not meet this axis in precisely in the same point, but will cross it somewhat nearer the surface. In short, the constant ratio or index of refraction will be that of the distances of the actual focus from the centre of the sphere, and from the point of external impact. Since an arc differs from its sine by a quantity nearly proportioned to its cube, the deviation of the extreme rays from the correct focus, or what is called the spherical aberration, must likewise proceed in that ratio, and consequently will increase with extreme rapidity, as the aperture of the telescope is enlarged. It was now attempted to modify the figure of the object-glass, and to give it those curved surfaces which an intricate geometrical investigation marks out as fitted to procure a perfect concentration of all the refracted rays. Various contrivances were accordingly proposed for assisting the artist in working the lenses into a parabolic, or spheroidal shape, and thus obtaining the exact surfaces generated by the revolution of the different conic sections. All those expedients and directions, however, were found utterly to fail in practice, and nature seemed, in this instance, to oppose insurmountable barriers to human curiosity and research. Philosophers began to despair of effecting any capital improvement in dioptrical instruments, and turned their views to the construction of those depending on the principles of catoptrics, or formed by certain combinations of reflecting specula.

Gregory.

In 1663, the famous James Gregory, who in many respects may be regarded as the precursor, and, in some things, even the rival of Newton, published his *Optica Promota;* a work distinguished by its originality, and containing much ingenious research and fine speculation. In this treatise, a complete description is given of the reflecting te-

* ———— like the moon, whose orb,
Through optic glass, the Tuscan artist views,
At evening, from the top of Fesolé,
Or in Valdarno, to descry new lands,
Rivers, or mountains, in her spotty globe.——*Paradise Lost*, Book I. 286—291.

lescope, now almost universally adopted, consisting of a large perforated concave reflector combined with another very small and deep speculum placed before the principal focus. But such was still the low state of the mechanical arts in England, that no person was found capable of casting and polishing the metallic specula with any tolerable delicacy, and the great inventor never enjoyed the satisfaction and transport of witnessing the magic of his admirable contrivance. It was after the lapse of more than half a century, that Hadley,—to whom we likewise owe another instrument scarcely less valuable, the quadrant, or sextant, known by his name,—at last succeeded in executing the reflecting telescope. In the first attempt, silvered mirrors had been substituted for the specula; nor did the reflectors come to obtain much estimation, till, about the year 1733, the ingenious Mr Short distinguished himself by constructing them in a style of very superior excellence.

Hadley.

But, though thus late in guiding the efforts of artists, the optical treatise of Gregory proved the harbinger of that bright day which soon arose to illumine the recesses of physical science. The capacious mind of Newton, nursed in the calm of retirement and seclusion, was then teeming with philosophical projects. In 1665, when the tremendous visitation of the plague raged in London, and threatened Cambridge, and other places communicating with the capital, this sublime genius withdrew from the routine of the university to his rural farm near Grantham, and devoted himself to most profound meditation. Amidst his speculations in abstruse mathematics and theoretical astronomy, Newton was induced to examine the opinions entertained by the learned on the subject of light and colours. With this view, he had recently procured from the Continent some prisms of glass, to exhibit the phenomena of refraction. Having placed the axis of the prism or glass wedge at right angles to a pencil of light from the sun, admitted through a small hole of the window-shutter in a darkened room, he contemplated the glowing image or spectrum now formed on the opposite wall or screen. This illuminated space was not round however, as the young philosopher had been taught to expect, but appeared very much elongated, stretching out five times more than its breadth, and marked by a series of pure and brilliant colours. It was therefore obvious, that the colours were not confined to the margin of the spectrum, nor could proceed from any varied intermixture of light and shade; and the conclusion seemed hence irresistible, that the white pencil or solar beam is really a collection of distinct rays, essentially coloured and differently refracted; that the ray, for instance, which gives us the sensation of violet, is always more bent aside from its course by refraction, than the ray which we term green,—and that this green ray again is more refracted than the red. When the spectrum was divided by interposing partially a small screen, and each separate parcel of rays made to pass through a second prism, they still retained their peculiar colour and refractive property, but now emerged parallel, and not in diverging lines as at first. The sun's light is thus decomposed by the action of the prism into a set of primary coloured rays; and these rays, if they be afterwards recombined again in the same proportions, will always form a white pencil. It was hence easy to discern the real cause of the imperfection of dioptrical instruments, which is comparatively little influenced by the figure of the object-glass or spherical aberration, but proceeds mainly from the unequal refraction of light itself. The focal distance of the red ray, being, in the most favourable case, about one fortieth part shorter than that of the violet ray, the principal image is necessarily affected with mistiness, and its margin always encircled by a coloured ring, for each point of the remote object from which the light arrives, is not represented by a corresponding point in the image, but by a small circle composed of graduating colours, the centre being violet and the circumference red. This radical defect seemed at that time to be altogether irremediable. Newton had recourse therefore to the aid of catoptrics, and contrived his very simple, though rather incommodious reflecting telescope, consisting of a concave speculum, with a small plane one placed obliquely before it, to throw the image towards the side of the tube. This instrument he actually constructed; and with all its rudeness, it promised essential advantages to astronomy. The Newtonian reflector, after having been long neglected, was lately revived by Dr Herschel; and from its great simplicity and moderate dissipation of light, it is perhaps on the whole, not ill calculated for celestial observations.

Newton.

These unexpected and very important discoveries, which entirely changed the face of optics, were soon communicated to the Royal Society, and published in the *Philosophical Transactions* for 1672. They were not received however by the learned, with that admiration to which they were justly entitled, but gave occasion to so much ignorant opposition and obstinate controversy, that the illustrious author, thoroughly disgusted at such unmerited reception, henceforth, pursuing his experimental researches in silence, made no disclosure of them to the world, till more than thirty years afterwards, when his fame being mature, and his authority commanding respect, he suffered his Treatise on Optics to appear abroad. This celebrated production has long been regarded as a model of pure inductive science. The experiments which it relates appear ingeniously devised; the conclusions from them are drawn with acuteness, and pursued with exquisite skill; and the whole discourse proceeds in a style of measured and elegant simplicity. Though the researches were conducted by a process of strict analysis, the composition of the work itself is cast into the synthetical or didactic form, after the manner followed in the elementary treatises of the ancient mathematicians. But with all its beauty and undisputed excellence, it must be confessed that the treatise of optics is not exempt from faults and even material errors. We should betray the interests of science, if we ever yielded implicit confidence even to the highest master. It is the glory of Newton to have led the way in sublime discovery, and to have impressed whatever he touched with the stamp of profound and original genius. The philosopher paid the debt of human infirmity, by imbibing some tincture of the mystical spirit of the age, and taking a slight bias from the character of his studies. The difficult art of experimenting was still in its infancy, and inquirers had not attained that deli-

cacy and circumspection which in practice are indispensable for obtaining accurate results. Most of the speculations in the second and third books of Newton's Optics, as we shall afterwards have occasion to observe, are built on mistaken or imperfect views of some facts, which the admixture of extraneous circumstances had accidentally disguised. The very ingenious, but hasty, and often untenable hypotheses, which are subjoined, under the modest and seemingly hesitating title of *Queries*, have, on the whole, been productive of real harm to the cause of science, by the splendid example thus held forth to tempt the rashness of loose experimenters and of superficial reasoners. Even in the first book of Optics, some of the capital propositions are affected by hasty and imperfect statements. The term *refrangibility*, applied to the rays of light, is at least unguarded; it conveys an indistinct conception, and leads to inaccurate conclusions. The different refractions which the primary rays undergo are not absolute properties inherent in these rays themselves, but depend on the mutual relation subsisting between them and the particular diaphanous medium. When the medium is changed, the refraction of one set of rays cannot be safely inferred from that of another. Nay, in the passage among certain media, those rays which are designated as the most refrangible, will sometimes be the least refracted. To ascertain correctly therefore the index of refraction, it becomes necessary, in each distinct case, to examine the bearing or disposition of the particular species of rays, since the principle that the refraction of the extreme rays is always proportioned to that of the mean rays, involves a very false conclusion.

When Newton attempted to reckon up the rays of light decomposed by the prism, and ventured to assign the famous number *seven*, he was apparently influenced by some lurking disposition towards mysticism. If any unprejudiced person will fairly repeat the experiment, he must soon be convinced, that the various coloured spaces which paint the spectrum slide into each other by indefinite shadings; he may name four or five principal colours, but the subordinate divisions are evidently so multiplied, as to be incapable of enumeration. The same illustrious mathematician, we can hardly doubt, was betrayed by a passion for analogy, when he imagined, that the primary colours are distributed over the spectrum after the proportions of the diatonic scale of music, since those intermediate spaces have really no precise and defined limits. Had prisms of a different kind of glass been used, the distribution of the coloured spaces would have been materially changed. The fact is, that all Newton's prisms being manufactured abroad, consisted of plate or crown glass, formed by the combination of soda, or the mineral alkali, with silicious sand. The refined art of glass-making had only been lately introduced into England, and that beautiful variety called crystal, or flint-glass, which has so long distinguished this country, being produced by the union of a silicious material with the oxyd of lead, was then scarcely known. The original experimenter had not the advantage, therefore, of witnessing the varied effects occasioned by different prisms, which demonstrate, that the power of refraction is not less a property of the peculiar medium than of the species of light itself. He mentions, indeed, prisms formed with water confined by plates of glass; but the few trials which he made with them had evidently been performed with no sufficient attention. In spite of his habitual circumspection, he could not always restrain the propensity so natural to genius, that of hastening to the result, and of trusting to general principles more than to any particular details. But the same indulgent apology will not be conceded to some later authors. It is truly astonishing, that systematic writers on optics, in obvious contradiction to the most undoubted discoveries related by themselves, should yet repeat with complacency the fanciful idea of the harmonical composition of light.

Achromatic Glasses.

Admitting the general conclusion which Newton conceived himself entitled to draw from analogy and concurring experiment, that "the sine of incidence of every ray considered apart, is to the sine of refraction in a given ratio;" it was strictly demonstrable, that no contrary refractions whatever, unless they absolutely restored the pencil to its first direction, could collect again the extreme rays, and produce, by their union, a white light. Thus, let the ratios of the sines of the angles of incidence and refraction of the violet rays in their transit from air to other two denser mediums, be expressed by $1 : M$ and $1 : m$; and the like ratios of the red rays under the same circumstances, by $1 : N$, and $1 : n$; where $M$, $m$ and $N$, $n$ respectively denote the refracting indices of those extreme rays. It is manifest that the refracting indices corresponding to the passage of the violet and red rays from the first to the second medium, will be represented by $M-N$, and $m-n$. But, by hypothesis, $M : m :: N : n$ and consequently $M : m :: M-N : m-n$; so that the extreme rays would be still separated and dispersed in proportion to the mean extent of the final refraction. The great philosopher appears to have contemplated with regret the result of his optical principle, and he had the penetration to remark, that, if a different law had obtained, the proper combination of distinct refracting media would have corrected the spherical aberration. With this view, he would propose for the object-glass of a telescope, a compound lens, consisting of two exterior meniscuses of glass, their outsides being equally convex, and their insides of similar but greater concavity, and having the interior space filled with pure water, as in the figure annexed.

He gives a rule, though without demonstration, and evidently disfigured or imperfect, for determining the curvature of the two surfaces: "And by this means," he subjoins, "might telescopes be brought to sufficient perfection, were it not for the different refrangibility of several sorts of rays. But, by reason of his different refrangibility, I do not see any other means of improving telescopes by refractions alone, than that of increasing their lengths."

These remarks appeared to preclude all attempts to improve the construction of the refracting telescope. Brightness and range of sight were sacrificed to distinctness. Instead of enlarging the aperture, recourse was had to the expedient of increas-

Achromatic Glasses.

ing the length of the focus. For nice astronomical observations, telescopes were sought of the highest magnifying powers, and their tubes had by degrees been extended to a most enormous and inconvenient size. But the famous Dutch mathematician,

Huygens.

Huygens, contrived to supersede the use of these in certain cases, by a method which required, however, some address. Many years afterwards the reflecting, or rather catadroptic, telescope of the Gregorian construction, was executed with tolerable perfection. But a long period of languor succeeded the brilliant age of discovery. Not a single advance was made in the science of light and colours, till thirty years after the death of Newton.* His immortal *Principia* had not yet provoked discussion, and philosphers seemed inclined to regard the conclusions in the *Treatise of Optics* with silent and incurious acquiescence. This memorable fact not only evinces the danger of yielding, in matters of science, implicit confidence even to the highest authority, but shows, amidst all the apparent bustle of research, how very few original experiments are made, and how seldom these are again repeated with the due care and attention.

The impossibility of correcting the colours in object-glasses of telescopes was therefore, a principle generally adopted; though some vague hopes, grounded chiefly on the consideration of final causes, were still at times entertained, of removing that defect. As the eye consists of two distinct humours, with a horny lens or cornea interposed, it was naturally imagined, that such a perfect structure should be imitated in the composition of glasses. This inviting idea is concisely mentioned by David Gregory, the nephew of James, in his little tract on Dioptrics. It has also been stated that a country gentleman, Mr Hall of Chesterhall in Worcestershire, discovered, about the year 1729, the proper composition of lenses by the united segments of crown and flint glass, and caused a London artist, in 1733, to make a telescope under his directions, which was found on trial to answer extremely well. But, whatever might be the fact, no notice was taken of it at the time, nor indeed till very long after, when circumstances had occurred to call forth public attention.

The Newtonian principle was first openly rejected, and a discussion excited, which eventually led to a most valuable discovery in optics, by a foreign mathematician of great celebrity and transcen-

Euler.

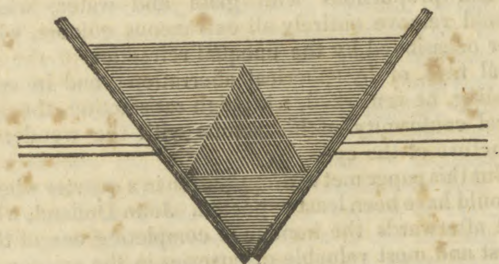
dent talents. Leonard Euler was one of those rare mortals who arise, at distant intervals, to shed unfading lustre on our species. Endowed with a penetrating genius and profound capacity, he was capable of pursuing his abstruse investigations with unremitting ardour and unwearied perseverance. To him the modern analysis stands chiefly indebted for its prodigious extension; and he continued to enrich it in all its departments, with innumerable improvements and fine discoveries, during the whole course of a most active, laborious, and protracted life. Unfortunately the philosophical character of Euler did not correspond to his superlative eminence as a geometer. Bred in the school of Leibnitz, he had imbibed the specious but delusive metaphysics of the *sufficient reason*, and of the necessary and absolute constitution of the laws of nature. He was hence disposed in all cases to prefer the mode of investigating *à priori*, and never appeared to hold in due estimation the humbler yet only safe road to physical science, by the method of experiment and induction. Euler expressed the indices of refraction by the powers of a certain invariable root, and fancied that the exponents of those powers are proportional, for the several rays in different media. Instead of making, in short, the numbers themselves proportional, as Newton had done, he assigned this property to their logarithms. In the *Berlin Memoirs* for 1747, he inserted a short paper, in which he deduced from his optical principle, by a clear analytical process conducted with his usual skill, the composition of a lens formed after certain proportions with glass and water, which should remove entirely all extraneous colours, whether occasioned by the unequal refraction of the several rays, or by spherical aberration; and in concluding, he remarked, with high satisfaction, the general conformity of his results with the wonderful structure of the eye.

John Dolland.

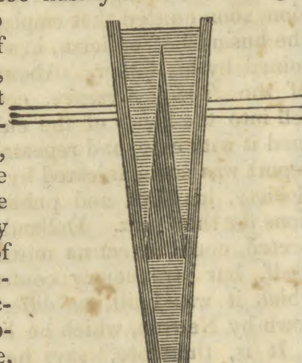
But this paper met with opposition in a quarter where it could have been least expected. John Dolland, who had afterwards the honour of completing one of the finest and most valuable discoveries in the science of optics, was born in 1706, in Spital Fields, of French parents, whom the revocation of the edict of Nantes had compelled to take refuge in England, from the cruel persecution of a bigotted and tyrannical court. Following his father's occupation, that of a silk-weaver, he married at an early age; and being fond of reading, he dedicated his leisure moments to the acquisition of knowledge. By dint of solitary application, he made some progress in the learned languages; but he devoted his main attention to the study of geometry and algebra, and the more attractive parts of mixed or practical mathematics. He gave instructions in these branches to his son Peter, who, though bred to the hereditary profession, soon quitted that employment, and commenced the business of optician, in which he was afterwards joined by his father. About this time, the volume of the *Berlin Memoirs*, containing Euler's paper, fell into the hands of the elder Dolland, who examined it with care, and repeated the calculations. His report was communicated by Mr Short to the Royal Society, in 1752, and published in their Transactions for that year. Dolland, as might well be expected, could detect no mistake in the investigation itself, but strenuously contested the principle on which it was built, as differing from the one laid down by Newton, which he held to be irrefragable. "It is, therefore," says he, rather uncourteously

* The fine discovery of the apparent aberration of the fixed stars, made by our countryman Dr Bradley, in 1729, cannot be justly deemed an exception to this remark. It belongs more to astronomy than to optics, and is indeed merely the result, however important, of the progressive motion of light, detected near sixty years before by the Danish philosopher Roemer, combined with the revolution of the earth in her orbit.

and certainly with little of the prophetic spirit, "it is, therefore, somewhat strange that any body now-a-days should attempt to do that which so long ago has been demonstrated impossible." The great Euler replied with becoming temper, but persisted in maintaining that his optical principle was a true and necessary law of nature, though he frankly confessed that he had not been able to reduce it yet to practice. The dispute now began to provoke attention on the Continent. In 1754, Klingenstierna, an eminent Swedish geometer, demonstrated that the Newtonian principle is in some extreme cases incompatible with the phenomena, and therefore ought not to be received as an undoubted law of nature. Thus pressed on all sides, Dolland at length had recourse to that appeal, which should have been made from the beginning,—to the test of actual experiment. He constructed a hollow wedge with two plates of glass, ground parallel, in which he laid inverted a common glass prism, and filled up the space with clear water, as in the annexed figure.



He now continued to enlarge the angle of the wedge, till the refraction produced by the water came to counterbalance exactly the opposite refraction of the glass, which must obtain, whenever an object is seen through the compound prism, without change of direction, in its true place. But contrary to what he so firmly expected, the external objects appeared glaringly bordered with coloured fringes, as much indeed as if they had been viewed through a glass prism with an angle of thirty degrees. It was therefore quite decisive, that Newton had not performed his experiment with scrupulous accuracy, and had trusted rather too hastily to mere analogical inference. But to remove every shadow of doubt from the subject, Mr Dolland, finding that large angles were inconvenient for observation, ground a prism to the very acute angle of nine degrees, and adjusted, by careful trials, a wedge of water to the same precise measure of refraction. Combining the opposite refractions as before, he beheld, on looking through the apparatus (as here represented) their various objects real position, but distinctly marked with the prismatic colours.

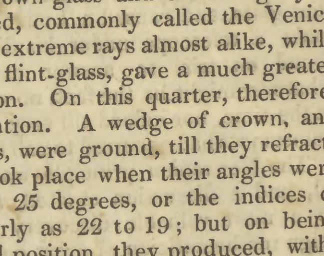




In these experiments, although the mean ray pursues the same undeviating course, the extreme rays which enter parallel with it, emerge from the compound prism, spreading out on both sides.

The capital point being completely ascertained, Dolland next tried so to adapt the opposite refractions, as to destroy all extraneous colour. This effect he found to take place, when the angle of the wedge had been farther increased, till the refracting power of the water was to that of the glass in the ratio of five to four. His conclusive experiments were made in 1757, and he lost no time in applying their results to the improvement of the object-glasses of telescopes. Following the proportion just ascertained, he conjoined a very deep convex lens of water, with a concave one of glass. In this way, he succeeded in removing the colours occasioned by the unequal refraction of light; but the images formed in the foci of the telescopes so constructed, still wanted the distinctness which might have been expected. The defect now proceeded, it was evident, merely from spherical aberration; for the excess of refraction in the compound lens being very small, the surfaces were necessarily formed to a deep curvature.

But this partial success only stimulated the ingenious artist to make farther trials. Having proved that the separation of the extreme rays, or what has been since termed the *dispersive power*, is not proportioned to the mean refraction, in the case of glass and water; he might fairly presume, that like discrepancies must exist among other diaphanous substances, and even among the different kinds of glass itself. The charm of uniformity being once dispelled, he was encouraged to proceed, with the confident hope of ultimately achieving his purpose. His new researches, however, were postponed for some time by the pressure of business. But, on resuming the inquiry, he found the English crown-glass and the foreign yellow or straw-coloured, commonly called the Venice glass, to disperse the extreme rays almost alike, while the crystal, or white flint-glass, gave a much greater measure of dispersion. On this quarter, therefore, he centered his attention. A wedge of crown, and another of flint-glass, were ground, till they refracted equally, which took place when their angles were respectively 29 and 25 degrees, or the indices of refraction were nearly as 22 to 19; but on being joined in an inverted position, they produced, without changing the general direction of the pencil, a very different divergence of the compound rays of light. He now reversed the experiment, and formed wedges of crown and flint-glass to such angles, as might destroy all irregularity of colour, by their opposite dispersions. When this condition was obtained, the refractive powers of those wedges of crown and flint-glass were nearly in the ratio of three to two, and consequently the sines of half their angles, or the angles



themselves, if small, were as 33 to 19, or nearly as 7 to 4. The rays which enter parallel now escape likewise parallel, but all of them deflected equally from their course.

The appearance was rendered still more conspicuous, by repeating the combination of the glass wedges, as in the figure here adjoined. It will be perceived that the pencils of rays which enter at equal distances on both sides of the common junction, must nearly meet in the same point of the axis, for in small arcs the chords are almost proportional to the arcs themselves. This arrangement indeed, with the projecting wedge of crown-glass in front, represents actually the composition of an object glass, formed of two distinct and opposing lenses, which would produce a similar effect. It was only required to apply a semi-convex lens of crown-glass before a semi-concave one of flint-glass, such that the curvature of the former be to that of the latter nearly as 7 to 4; but with some modifications in this ratio, according to the peculiar qualities of the glass. [The figure annexed represents this combination.] But the depth of the lenses might be diminished, by giving them curvature on both sides. Thus, if a double convex of crown-glass were substituted, of the same power, and consequently with only half the curvature on each side; the lens of flint-glass adapted to it having, therefore, their common surface of an equal concavity, would need, in order to produce the former quantity of refraction, and consequently to maintain the balance of opposite dispersions, a concavity eight times less than before on the other surface. Or if a double concave of flint-glass, with half its first depth, were used, the front convexity of the lens of crown-glass would be five-sevenths of the former curvature, as here represented. The surface where the two lenses are united may hence have its curvature changed at pleasure, but every alteration of this must occasion corresponding changes in the exterior surfaces.

In all these cases, the refraction of the convex pieces being reduced to one-third by the contrary refraction of the concave piece, the focal distance of the compound glass must be triple of that which it would have had singly. But a most important advantage results from the facility of varying the adaptation of the lenses, for, by rightly proportioning the conspiring and counteracting curvatures, it was possible to remove almost entirely the errors arising from spherical aberration. This delicate problem, Mr Dolland was the better prepared to encounter, as he had already, in 1753, improved the telescope materially, by introducing no fewer than six eye-glasses, disposed at proper distances, to divide the refraction. The research itself, and the execution of the compound lens, presented peculiar difficulties; but the ingenuity and toilsome exertions of the artist were at length, in 1758, rewarded with complete success. "Notwithstanding," says he, in concluding his paper, "so many difficulties as I have enumerated, I have, after numerous trials, and a resolute perseverance, brought the matter at last to such an issue, that I can construct refracting telescopes, with such apertures and magnifying powers, under limited lengths, as, in the opinion of the best and undeniable judges, who have experienced them, far exceed any thing that has been produced, as representing objects with great distinctness, and in their true colours."

The Royal Society voted to Mr Dolland, for his valuable discovery, the honour of the Copley medal. To this new construction of the telescope, Dr Bevis gave the name of *Achromatic* (from *α*, *privat.* and *χρωμα*, *colour*,) which was soon universally adopted, and is still retained. The inventor took out a patent, but did not live to reap the fruits of his ingenious labours. He died in the year 1761, leaving the prosecution of the business to his son and associate, Peter Dolland; who realized a very large fortune, by the exclusive manufacture, for many years, of achromatic glasses, less secured to him by the invidious and disputed provisions of legal monopoly, than by superior skill, experience, and sedulous attention. In 1765, the younger Dolland made another, and final improvement, to which his father had before advanced some steps. To correct more effectually the spherical aberration, he formed the object-glass of three instead of two lenses, by dividing the convex piece; or he inclosed a concave lens of flint-glass between two convex lenses of crown-glass, as exactly represented in the figure here annexed. He showed a telescope of this improved construction, having a focal length of three feet and a half, with an aperture of three inches and three quarters, to the celebrated Mr Short, who tried it with a magnifying power of one hundred and fifty times, and who, superior to the jealousy of rivalship, and disposed to patronize rising merit, most warmly recommended it, and declared that he found "the image distinct, bright, and free from colours."

Peter Dolland.

What were the curvatures of those distinct component lenses, Dolland has not mentioned, and perhaps he rather wished to conceal them. The Duke de Chaulnes was enabled, however, by means of a sort of micrometer, to ascertain the radii of the several surfaces, in the case of one object-glass of the best composition. He found these radii, beginning with the front lens, to be respectively $311\frac{1}{2}$, 392; 214, 294; 294, and $322\frac{1}{2}$, in French lines, which correspond, in English inches, to 32.4, 40.8; 22.2, 30.6; 30.6 and 33.5. If these measures were correct, however, it would follow, that the middle lens of flint-glass was not perfectly adapted to the curvature of the lens of crown-glass placed immediately

Achromatic Glasses.

before it. Similar admeasurements have been repeated by others, but the results differ considerably, and no general conclusion can be safely drawn. There is no doubt, that the artist varied his practice, according to the nature of the glass which he was obliged to use. The more ordinary proportions for the curvatures of the component lenses would be represented by a truncated prism, formed with a double cluster of wedges, the outer ones having angles of 25° 53′, and 14° 27′, and consisting of crown-glass, and the inner one made of flint-glass, with an inverted angle of 27° 3′. These two wedges of crown-glass would produce the same refraction, it might be shown, as a single one having an angle of 40° 54′, wherefore this refraction will be diminished by the opposite influence of the wedge of flint-glass, in the ratio of 49 to 16, or reduced to nearly one-third.

Thus was achieved and fully carried into practical operation, the finest and most important detection made in optics since the great discovery of the unequal refraction of the several rays of light. It was drawn forth by a long series of trials, directed with judgment and ingenuity, but certainly very little aided by the powers of calculation. Such a slow tentative procedure was perhaps the best suited, however, to the habits of an artist, and it had at least the advantage of leaving no doubt or hesitation behind it. On this occasion, we cannot help being struck with a remark, that most of those who have ever distinguished themselves in the philosophical arts by their original improvements, were seldom regularly bred to the profession. Both the Dollands, we have seen, began life with plying at the loom; Short had a liberal education, being designed for the Scottish church, but, indulging a taste for practical optics, he afterwards followed it as a trade, in which he rose to pre-eminence; Ramsden, whose ingenuity and exquisite skill were quite unrivalled, was at first, we believe, a clothier in Yorkshire; Tassie, who revived or created among us the nice art of casting gems, was originally a stonemason at Glasgow; and Watt, who, by his very happy applications of mechanics, and his vast improvements on the steam-engine, has, more than any other individual perhaps, contributed to the great national advancement, was early an ivory-turner in that same city, and can still find pleasure, in his declining years, with the amusement of the lathe. We might easily enlarge this catalogue; but enough has been said to prove the justness of the observation, and it suggests reflections which are not favourable to fixed and systematic plans of education.

Subsequent improvements.

The theory of achromatic telescopes embraced in all its extent, opened a field of abstruse and difficult investigation. But the English mathematicians at that period, though they might appear to be especially invited to the discussion, very generally neglected so fine an opportunity for the exercise of their genius. They coldly suffered the artists to grope their devious way, without offering to guide their efforts by the lights of science. On the continent, the geometers of the first order were all eager to attempt the solution of problems at once so curious and important. For several years subsequent to 1758, the Transactions of the foreign academies were filled with memoirs on the combination of achromatic lenses, displaying the resources and refinements of the modern analysis, by Euler, Clairaut, and D'Alembert,—by Boscovich, Klingenstierna, Kæstner, and Hennert. On this, as on other occasions, however, we have to regret the want of close union between artists and men of science. Those profound investigations are generally too speculative for any real use; they often involve imperfect or inaccurate data; and the results appear wrapped in such comprehensive and intricate formulæ, as to deter the artist from endeavouring to reduce them into practice. We should have thought it preferable, on the whole, not to load the solution of the main problem with minute conditions, but to aim at a few general rules, which could afterwards be modified in their application according to circumstances. All this might have been accomplished, without scarcely travelling beyond the limits of elementary geometry.

Euler.

Euler and his adherents at Berlin were still not disposed to abandon his favourite optical hypothesis. It was even pretended that Dolland must have owed his success to a nice correction of spherical aberration, and not to any really superior dispersive power belonging to the flint-glass. But the philosopher afterwards yielded to the force of reason and testimony; and, collecting his various optical papers, he published, in the successive years 1769, 1770, and 1771, a complete treatise on Dioptrics, occupying three quarto volumes, which contain a store of ingenious and elegant disquisitions.

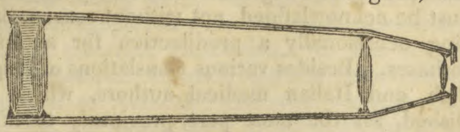
Clairaut.

The last memoir which Clairaut ever wrote, related to achromatic glasses. D'Alembert prosecuted the subject with diligence and ardour; and the volumes of his *Mathematical Opuscules*, published between the years 1761 and 1767, contain some elaborate dioptrical investigations. Among other conclusions which he deduced from his multiplied researches, he proposed a new composition for the object-glass of a telescope, to consist of three lenses, the outmost one being a meniscus of crown-glass, or having a convex and a concave surface, then a meniscus of flint-glass in the middle, and adapted to this, on the inside, a double convex of crown-glass. Of all the continental works, however, which treat of achromatic combinations, the tracts of Boscovich, who possessed a very fine taste for geometry, may be held as the simplest and clearest. We cannot help noticing, by the way, a curious theorem of his concerning the form and arrangement of eye-glasses, which would be free from irregular colours. It is, that the correction will be produced by means of two lenses of the same kind of glass, if separated from each other by an interval, equal to half the sum of their focal distances. This principle furnishes a very simple construction for the common astronomical telescope, through which the objects are seen inverted. In the annexed figure, the object-glass, as usual, is achromatic, being com-

D'Alembert.

Boscovich.

posed of two convex lenses of crown-glass, with a



concave one of flint-glass fitted between them; but the eye-glass consists of two distinct lenses of crown-glass, both of them convex, and exactly similar, the first having every dimension triple that of the other, and their mutual distance double the focal length of the smaller.

Supposing, however, that the errors occasioned by spherical aberration were completely removed, the principle of achromatic combination is yet far from being so perfect as it has often been represented. Although the opposite dispersions of the flint and of the crown-glass should bring together the extreme rays, we are not, from this coincidence, warranted to infer that the several intermediate rays would likewise be accurately blended. In fact, a wedge of flint-glass not only separates all the rays much more than a similar one of crown-glass, but divides the coloured spaces after different proportions. While the combined lenses formed of those two kinds of glass, give an image entirely free from the red and violet borders, they may still introduce secondary shades of green or yellow, sufficient to cause a certain degree of indistinctness. The mode of correcting this defect would be, to produce a counterbalance of colours, by conjoining several media endued with different refractive and dispersive powers. In these qualities, crown-glass itself admits of some variation, owing to the measure of saline ingredient; but flint-glass differs widely with regard to its optical properties, owing chiefly to the diversified proportion of minium or oxyd of lead which enters into its composition, and partly to the variable admixture of manganese employed to discharge the yellow tint occasioned by the lead. Manifest advantages therefore would result from a choice combination of three or more varieties of glass, since both the primary and the secondary deviations of colour would be corrected. Without pretending to any theoretical perfection, every thing really wanted in practice would be thus attained. A series of nice experiments on the optical relations of glass, could not fail, by their results, to reward the assiduity of the ingenious artist. He would trace and determine the separate influence exerted on the refractive and dispersive powers by soda in the crown-glass, and by minium and manganese in the flint-glass. It is highly probable, that with perseverance he might discover a vitreous composition better adapted than any yet known for achromatic purposes. It is very generally believed, that the achromatic telescopes, now manufactured in London, are not of the same excellence with those first made by Peter Dolland. This declension of such a beautiful art, has frequently been imputed to the baneful operation of a severe and oppressive system of excise. Whether the new mode of charging the duty on glass at the annealing arch, has produced any beneficial effects, we are still to learn.

r R. Blair. An extensive and ingenious set of experiments on the dispersive powers of different liquids, was undertaken, about the year 1787, and successfully prosecuted for some time afterwards, by Dr Robert Blair, for whom there had been recently created, under Royal patronage, the chair of practical astronomy in the University of Edinburgh, one of the very few professorships in that distinguished seminary, which has been suffered to remain inefficient and merely nominal. Of these experiments, a judicious account was in 1790 communicated by their author to the Royal Society of Edinburgh, in a paper drawn up with evident ability, but rather too diffuse, and unnecessarily digressive. Dr Blair had a very small brass prism perforated with a hole, which he filled with a few drops of the liquid to be examined, and confined each end by a plate of glass with parallel surfaces. He then applied, inverted to the prism in succession, a number of glass wedges which he had provided of different angles, and observed when the bars of the window, seen through this compound prism, appeared colourless; the angle of the wedge now expressed the relative dispersive power of the liquid. This way of experimenting was sufficiently simple, but a more accurate and expeditious method might have easily been devised. For instance, if the prism, furnished with a graduated arch, had remained fixed, and a single glass wedge made to turn upon it, and present successive inclinations to the observer; the refracting angle at which the irregular colours were united, could be deduced by an easy calculation. Dr Blair found by his trials, that muriatic acid, in all its combinations, but particularly with antimony and mercury, shows a very great dispersive power. The essential oils stood the next with regard to that property, though differing considerably among themselves. In Dr Blair's first attempts to improve the achromatic telescope, he conjoined two compound lenses, the one formed with a double concave of crown glass, and a semi-convex of essential oil, and the other composed of a double convex filled with essential oil, of great dispersive power, and of a semi-concave, likewise containing essential oil, but less apt for dispersion. This very complex arrangement seemed, however to produce the desired effect, not only discharging from the image the extreme fringes of red and violet, but excluding also the intermediate shades of green or yellow A simpler combination was afterwards used, requiring merely one liquid, composed of muriatic acid joined with antimony, or the triple salt of that acid united in certain proportions to ammonia and mercury. This liquid being accurately prepared, was inclosed between two thin glass shells to form a double convex lens; on the front was applied a semiconvex of crown glass, and a meniscus of the same material behind, the whole being secured by a glass ring. An object-glass so constructed seemed to perform its office with great perfection, effectually correcting both the primary and the secondary admixture of colours. This kind of eye-glass, Dr Blair proposed to denominate *aplanatic* (from α *privat.* and πλαναω to *err* or *wander*), and he obtained a patent for his invention. The late George Adams, optician in Fleet Street, was entrusted with the fabrication and sale

Achromatic Glasses || Ackermann.

of the telescopes thus constructed. Some of them were said to answer extremely well; but, whether from want of activity on the part of the tradesman, or from defect of temper in the patentee, these instruments never acquired much circulation. It was alleged that the liquid by degrees lost its transparency. Indeed we suspect that there is no combination in which liquids are concerned, which can be judged sufficiently permanent for optical purposes. It seems hardly possible to preclude absolutely the impression of the external air; the liquid must, therefore, have a tendency both to evaporate and to crystallize; and, in the course of time, it will probably, by its activity, corrode the surfaces of the glass.

French achromatic Telescopes.

The manufacture of achromatic telescopes in England furnished, for a long period, a very profitable article of exportation. Even after the introduction of those instruments was prohibited by several foreign governments, the object-glasses themselves, in a more compendious form, were smuggled abroad to a large amount. In fact, no flint-glass of a good quality was then made on the Continent. A very material alteration, however, in that respect, has recently taken place, at least in France; where the stimulus impressed by the revolution has worked so many changes, and where ingenuity and science, in most of the mechanical arts, have so visibly supplied the scantiness of capital. The French now construct achromatic telescopes, equal, if not superior, to any that are made in England. Dolland formerly had an agent settled at Paris for vending his glasses; but, during the gleam of peace which followed the success of the allied sovereigns, it was found that this establishment could no longer be resumed with any prospect of advantage.

For the mathematical investigations relative to the figure of lenses, and to spherical aberration, see the articles CATOPTRICS and DIOPTRICS in this Supplement. (D.)

ACKERMANN, (JOHN CHRISTIAN GOTTLIEB), a very learned physician and professor of medicine, was born at Zeulenrode in Upper Saxony, in the year 1756. Having acquired the rudiments of his medical education under the tuition of his father, who was also a physician, he proceeded to Jena and to Gottingen, and studied under Baldinger and Heyne. On quitting the latter university, he established himself in practice at Stendal, the numerous manufactories of which place enabled him to contribute many important observations to the translation of Rammazzini's *Treatise of the Diseases of Artificers*, which he published in 1780-83. After practising here several years, he was appointed public Professor in ordinary of medicine, in the university of Altorf in Franconia, which office he continued to fill with great repute to the time of his death, which took place in 1801. All Dr Ackermann's works display great erudition. To the history of medicine he contributed many valuable articles; the disquisitions, in particular, on the lives and writings of Hippocrates, Galen, Theophrastus, Dioscorides, Aretæus, and Rufus Ephesius, which he furnished to Harles's edition of *Fabricius' Bibliothæca Græca*, are justly esteemed as masterpieces of critical research. As a practitioner he appears to have possessed no mean talents for observation; though he has been accused, and, it must be acknowledged, not without reason, of betraying occasionally a predilection for antiquated hypotheses. Besides various translations of English, French, and Italian medical authors, which were published, for the most part, previously to his removal to Altorf, the following works have appeared under his name:—1. *De Trismo, Commentatio Medico.* 8vo, 1775.—2. *De Dysenteriæ Antiquitatibus liber bipartitus.* 8vo, 1777.—3. *Ueber die Krankheiten der Gelehrten.* 8vo, 1777.—4. *The Life of John Conrad Dippel*, in German. 8vo, 1781.—5. *Parabilium Medicamentorum Scriptores Antiqui:* Sexti Placiti Papyriensis *de Medicamentis ex Animalibus;* Lucii Apulei *de Medicamentis ex Herbis, cum Notis.* 8vo, 1788.—6. *H. D. Gaubii Institutiones Pathologiæ Medicæ, cum Additamentis, J. C. G. A.* 8vo, 1787.—7. *Regimen Sanitatis Salerni, c. Studii Medici Salernitani Historia Præmissa.* 8vo, 1790.—8. *Institutiones Historiæ Medicinæ.* 8vo, 1792.—9. *Institutiones Therapiæ Generalis.* 2 tom. 8vo, 1793-95.—10. *Handbuch der Kriegsarzneykunde.* 2 tom. 8vo, 1795.—11. *Opuscula ad Historiam Medicinæ pertinentia.* 8vo, 1797.—12. *Bemerkungen über die Kentniss und Kur einiger Krankheiten.* 8vo, 1794-1800.—13. *Pathologische-Praktische Abhandlung über die Blähungen, für Aertze und Kranke bestimmt.* 8vo, 1800. (E.)

Ackermann || Acosta.

ACOSTA, (JOSEPH D',) a celebrated Spanish author, was born at Medina del Campo, about the year 1539. In 1571, he went to Peru as a Provincial of the Jesuits, having entered into that society in his fourteenth year. After a residence in America of seventeen years, he returned to his native country, and became in succession visitor for his order of Arragon and Andalusia, superior of Valladolid, and rector of Salamanca; in which city he died in February 1600.

About ten years before his death, he published at Seville, in one volume quarto, his valuable work entitled *Historia Natural y Moral de las Indias.* The two first books of this history were written during his residence in Peru, and were published separately after his return to Spain, in the Latin language, with this title: *De Natura Novi Orbis, libri duo.* He afterwards translated them into Spanish, and added to them other five books, the whole composing a connected work, under the first mentioned title. This work, which has been translated into all the principal languages of Europe, is written on a regular and comprehensive plan. The five first books are employed upon the physical geography and natural history of that portion of America which had been conquered or discovered by the Spaniards; the fifth and sixth upon the manners, religion and civil institutions of the inhabitants; and the last, upon the history of the Mexicans, from their origin till the period of their subjugation. Dr Robertson pronounces Acosta, "an accurate and well-informed writer." Among other things, he treats the subject of climate in a more philosophical manner, than could have been expected in a writer of that age, and of his order. "He was the first philosopher," says the eminent author just quoted, "who endeavoured to account for the different degrees of heat in the old and new

Acosta.

continents, by the agency of the winds which blow in each;"—a theory which was afterwards adopted by Buffon, and supported with his usual powers of copious and eloquent illustration. In the course of these discussions, Acosta frequently comments upon the opinion of Aristotle, and other ancient philosophers, that the middle zone of the earth was so much scorched by the rays of the sun, as to be destitute of moisture and verdure, and totally uninhabitable. This notion seems to have held its ground in the Schools, even after the discovery of South America had disclosed the magnificent scenery and stupendous rivers of the tropical regions. It appears to have been thought a sort of impiety to question a dogma of such ancient date, and sanctioned by the assent of all the school divines. We learn, from a curious passage in Osborne's *Miscellany of Essays, Paradoxes, and Letters*, that the exposing of this ancient error in geography, was one of the circumstances which brought upon the famous Sir Walter Ralegh the charge of general scepticism and atheism. Acosta mentions, that, when he went to America, his mind was deeply imbued with frightful notions of this supposed burning zone, and that his surprise was great, when he beheld it so different from what it had been represented in the "ancient and received philosophy." "What could I do then," says he, "but laugh at Aristotle's meteors and his philosophy?"

Having said thus much in regard to one of the most curious and valuable of the earlier accounts of the new world, it may be proper to add, that, in speaking of the conduct of his countrymen, and the propagation of their faith, Acosta is in no respect superior to the other prejudiced and fanatical writers of his country and age. Though he acknowledges that the career of Spanish conquest was marked by the most savage cruelty and oppression, he yet represents this people as the chosen instruments of the Deity, for spreading the truths of the gospel among the nations of America. He accordingly recounts a variety of miracles, as a proof of the constant interposition of Heaven, in favour of these merciless and rapacious invaders. It will appear from the following curious passage, that he even makes the great enemy of mankind himself, a co-operator in that scheme of conversion for which he represents the Spaniards to have been predestined. "That" says he, "which is difficult in our law to believe, has been made easy among the Indians; because the *Devil* had made them comprehend even the self same things, which he had stolen from our evangelical law,—as their manner of confession, their adoration of three in one, and such like; the which, against the will of the enemy, have holpen for the easy receiving of the truth."

Besides his History, Acosta wrote the following works: 1. *De Promulgatione Evangelii apud Barbaros.*—2. *De Christo Revelato.*—3. *De Temporibus Novissimis*, libros vi.—4. *Concionum*, tomos iii. All of these works were, in their day, frequently reprinted; but it is only by his history that his name is now known in the literary world. The English translation, from which we have taken the preceding extracts, was published at London, in quarto, in the year 1604, and is now rather a scarce book.

Acoustics.

ACOUSTICS. The doctrine of sound is unquestionably the most subtle and abtruse in the whole range of physical science. It has given occasion, in recent times, to much controversy and discussion, and has eventually called forth all the mighty resources of a refined and elaborate calculus. Yet an evident obscurity still remains to overcloud the subject. The discrepancies between theory and observation have been made entirely to disappear from astronomy, which has at last attained a degree of perfection befitting the sublimity of the science. But some latent suspicions pervade the structure of acoustics, sufficient to disturb that feeling of confidence which is calculated to invigorate our pursuits. The general theory of sound, and its application to a variety of curious philosophical amusements, have been explained in the body of the work. We purpose, however, to reconsider the subject at large, and to examine closely the bases on which it rests. But we must content ourselves at present with a few sketches, reserving our extended remarks for their several distinct heads, in hopes that, during the progress of this Supplement, we shall be able to collect more accurate and complete materials.

Sound conveyed by a certain tremor.

The impression of sound is conveyed by means of a certain tremor or internal agitation, which shoots, with more or less celerity and force, through any substance, whether solid or fluid. Nor is it requisite that the conducting medium should belong to the class of bodies which are commonly denominated elastic. In fact, all bodies whatever, in the minute and sudden alterations of their form, exert a perfect elasticity, and only seem to want this energy when they undergo such great changes, that their component particles take a new *set* or arrangement, which prevents the full effect of reaction.

It is not every kind of tremulous motion, however, that will excite the sensation of sound. A certain degree of force and frequency in the pulsations appears always necessary to affect our sense of hearing. Yet the impression of sound is not confined to the mere external organ; the auditory nerves have a considerable expansion, and sympathize with those of taste and of smell. The only inlet of vision is by that very narrow aperture, the pupil of the eye; but the reception of sound partakes more of the character of the general sense of feeling, which, though most vivid at the extremities of the fingers, is likewise diffused over the whole surface of the body. The intimation of the ear is accordingly assisted by the consent of the palate, the teeth, and the nostrils. Fishes hear very acutely under water, though the organ itself lies so concealed in the head, as to have long escaped the diligence of anatomists.

It was formerly supposed, that the transmission of impulse through a solid body is perfectly instantaneous. This formed, indeed, one of the Cartesian tenets, which Newton himself has tacitly admitted. But accurate observations have since proved, that motion is always really progressive, and propagated in succession. Professor Leslie has shown that the darting of impact through any substance, whether hard or soft, is accomplished by the agency of the same interior mechanism as that of sound, and has fur-

nished the method of calculating, in some of the more difficult cases, the celerity of transmission.

All bodies essentially elastic.

All bodies may be considered as composed of physical points, without any sensible magnitude, but connected together by a system of mutual attraction and repulsion. When those integrant particles are compressed by external violence, a repulsive force is exerted to regain their first position; or if they be dilated, a corresponding attraction now draws them back to their neutral site of equilibrium. We may farther presume, that, in solids, these constituent forces are confined to the proximate particles only, but that, in the case of liquids or other fluids, they embrace the particles in their near vicinity, and include a sphere of action varying in its extent. Hence, the former suffer disruption, without bending or giving way to powerful pressure; while the latter, acting by a sympathetic union, gently recede and take a new arrangement. In fact, the attribute of hardness applied to body is only a relative, and not an absolute, quality; in the inferior degrees it relapses into softness, and softness again passes through interminable shades to the most yielding fluidity. The application of heat, by enlarging the system of internal connexion, generally promotes softness, and heightens the degree of fluidity itself. The effect is conspicuous in the increased flow from a capillary syphon, when kept warm. But even liquids, when struck with a blow so rapid and sudden as to preclude the sympathy of their adjacent molecules, will assume all the character of the hardest substances. This fact has a familiar illustration in the play of Duck and Drake; but it is beautifully exemplified in the successive rebounds made by cannon-shot, from the surface of the sea.

In confirmation of the remark, we may quote a very singular and curious circumstance, mentioned by travellers, relative to the method of catching fish, which is successfully practised in some of the more northern countries. The hardy peasant, when the smaller lakes and rivers of Lapland or Siberia are completely frozen over, as soon as he observes, through the clear ice, a fish, perhaps at a considerable depth, but lying close to the bottom, strikes a smart blow against the firm surface, and the impulse sent through the vertical column of water instantly stuns or kills his prey, which he draws up by a large hook let down through the hole just made in the ice.

If we conceive a conducting substance to be struck at one extremity, the proximate particles, yielding at first to the impulsion, will again expand themselves, like the recoil of a spring, and press against the next particles in the chain. The vibratory commotion will thus be conveyed, by a successive transfer of impressions, along the whole series of physical points. Analogous also to the oscillations of a spring or a pendulum, this multitude of concatenated internal pulses, whatever be the force or extent of agitation, will constantly be performed in the same instants of time. The celerity of transmission must depend on the elasticity of the medium compared with its gravity. This estimate is most readily obtained by determining what may be called the *modulus* of elasticity, or the height of a column of the same density as the conducting substance, whose weight would measure that elasticity; or, to speak more precisely, that the thousandth part of such a column, for instance, should be equivalent to the repulsive force, corresponding to a condensation of one thousandth part in the vibrating body.

*Modulus* of elasticity.

It may be demonstrated from the principles of dynamics, that the celerity of the transmission of impulse or sound through any medium, is equal to what a falling body would acquire in falling through half the height of the modulus of elasticity. Hence this celerity for each second will be expressed in English feet, by multiplying the square root of half the modulus by eight, or by extracting the square root of the modulus multiplied by thirty-two.

Celerity of sound through different solid bodies.

Mr Leslie has pointed out a very simple method for ascertaining the modulus of elasticity in the case of solid rods or planks, by observing, when they are laid in a horizontal position, with their ends resting against two props, the *swag* or curvature which they take. By an experiment of this kind, he found that Memel fir had a modulus equal to 671,625 feet. Wherefore, an impulse would shoot through the substance of a deal-board with the velocity of 4,636 feet each second, or about four times the rapidity of sound. Professor Chladni, who has thrown so much curious light on the convoluted curves, formed by vibrations spreading along the surface of solid bodies, inferred, from a very different procedure,—from the musical note which a bar of the substance emits when struck,—the celerity of the transmission of sound through iron and glass, which he reckoned for both at 17,500 feet, or above three miles each second, being more than fifteen times swifter than the ordinary communication through the atmosphere.

The rate with which the tremor of sound is transmitted through cast-iron, was very lately ascertained, from actual experiment, by the ingenious M. Biot. This philosopher availed himself of the opportunity of the laying of a system of iron pipes, to convey water to Paris. These pipes were about eight feet each in length, connected together with narrow leaden rings. A bell being suspended within the cavity, at one end of the train of pipes, on striking the clapper at the same instant against the side of the bell, and against the internal surface of the pipe, two distinct sounds were successively heard by an observer stationed at the other extremity. In these observations, M. Biot was often assisted by the late M. Malus, who has, too soon for the progress of science, been hurried away by death, after having opened the delicate discovery of the *polarization of light*. With a train of iron pipes of 2550 feet, or nearly half a mile, in length, the interval between the two sounds was found, from a mean of two hundred trials, to be 2.79 seconds. But the transmission of sound through the internal column of air, would have taken 2.5 seconds; which leaves .29″, for the rapidity of the tremor conducted through the cast-iron. From other more direct trials, it was concluded that the exact interval of time during which the sound performed its passage through the substance of the train of pipes, amounted only to 26-100th parts of a second; being ten or twelve times less than the ordinary transmission through the atmosphere.

Except the observations of M. Hassenfratz, in the famous subterranean quarries which extend under almost the whole of Paris, we are not acquainted with

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any attempts that have been made to measure the elasticity of stone or brick. Yet sound is conveyed through these materials with great effect. The rattling of a carriage on the street spreads a very sensible tremor along the most solid buildings and the stateliest edifices. If a large stone be rubbed against the outside of the wall of a house, it will occasion within doors a strange rumbling noise. A miner will strike his pick against the side of a long gallery, when he wishes to give intimation to his companion, who listens at the other extremity. But stones or bricks, without being directly excited, may yet form a part of the chain which transmits sound, by receiving the tremulous impressions from the air on the one side, and delivering them again to that fluid on the other. We all know how easily the voice is heard through a thin partition. The mode of obstructing the passage of sound is, either to employ very thick masonry, or to interrupt the facility of communication and transfer, by means of subdivisions opposed. Hence another distinct use of lath and plaster. Experiments on the elasticity of stones and other articles of building, are not only curious, but of real importance; for, in many cases, their efficient strength must depend on their fitness to resist incidental impressions. This consideration is peculiarly necessary, in selecting and combining the materials employed in the construction of bridges.

Supposed incompressibility of Water.

Respecting the elasticity of water and other liquids, our information is more satisfactory and complete. It was long held as an axiom, that the substance of water is absolutely incompressible. Yet the experiments on which this belief was grounded, would, if weighed attentively, point to an opposite inference. On such a subject, it were idle to cite Lord Bacon, whose credulity and ignorance of mathematical science betrayed him so often into false or shallow conclusions. The philosophers of the Florentine academy *del Cimento* tried the compression of water in three different ways, which are described in the account of their experiments printed in 1661. 1. Having provided two glass tubes terminated by hollow balls, they filled the one partly, and the other to excess, with pure water, and joined the tubes hermetically, so as to form one piece. Then applying heat to the first ball, till the water boiled, they forced its vapour to press against the column in the other stem. But, no contraction of the fluid took place, though a copper ball was afterwards substituted; and when the action of the heat was still farther urged, the tube at last burst with violence. 2. Into a glass tube, immediately above six pounds of water, they introduced eighty pounds of quick-silver, without causing any diminution of volume. 3. Their most noted experiment was, having filled a hollow silver ball with water by a small hole, afterwards soldered accurately, to give it a few smart blows with a hammer: when, far from suffering compression, the water was seen to ooze or spirt from the pores, as they imagined, of the silver.

Mr Boyle, whose practice it was generally to repeat the more striking experiments made on the Continent, had a round tin or pewter vessel filled carefully with water, and tightly plugged: The blow of a wooden mallet beat it flat, but, on piercing the tin with the point of a small nail, the confined water instantly sprung, to the height of two or three feet. About the year 1752, Dr Peter Shaw, who read public lectures in London, exhibited a stout copper ball of four inches in diameter, and filled with water by a small orifice, into which a screw was fitted, and forced to enter by turning an iron arm or lever: The globe was partly opened by this enormous squeeze, and the water spouted from the crevice as from a fountain.

These experiments all concur to show, that water is capable of sustaining an immense pressure without undergoing any very sensible contraction; but they prove, at the same time, the actual existence of such a contraction, since the projecting of the water, after a crack has once begun in the vessel that confines it, could only proceed from the evolution of an internal repulsive force.—Divers, accordingly, at considerable depths under water, hear distinctly the collision of two stones, or the remote ringing of a bell. Authentic instances are mentioned of sounds being transmitted audibly more than two miles through that fluid.

Compressibility of Water demonstrated by Mr Canton.

The compressibility of water was first demonstrated by the ingenious Mr Canton, in 1762, by a very simple and conclusive experiment. To a glass ball of rather more than an inch and half in diameter, he joined hermetically a tube about four inches long, and having a bore equal to the hundredth part of an inch. The relative capacity of this ball and of the stem, he ascertained by introducing mercury, and weighing nicely its separate portions. The stem was then marked by the edge of a file into divisions, corresponding each to the hundred thousandth part of the whole capacity of the ball. This instrument was now filled with distilled water, carefully purged of its adhering air, and placed under the receiver of a pneumatic machine; on producing an exhaustion, the water appeared constantly to swell, rising four divisions and three-fifths in the stem, or a space nearly equal to the mercurial expansion corresponding to half a degree of heat on Fahrenheit's scale. In a condensing engine, the water sunk just as much, for each additional pressure of an atmosphere,—the bulb remaining always at the same temperature, or at the fiftieth degree of Fahrenheit. Since the stem was left open, the pressure exerted by the air, both on the inside and the outside of the instrument, must in all cases have been precisely the same; and, consequently, the glass had no disposition to alter its figure, and modify the results. The contraction or expansion produced was, therefore, confined wholly to the body of water and to the thin shell of glass, of which indeed the influence might be rejected as insignificant. It was hence decided, that the purest water suffers a visible concentration or a diminution of its volume, under a powerful compression. But, in the course of his experiments, Mr Canton observed a curious circumstance, that water is more compressible in cold than in warm weather. Thus, the contraction, under a single incumbent atmosphere, amounted to 4.9 divisions, when the thermometer stood at 34°; but was only 4.4 divisions, when the

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heat rose to 64°. This singular fact might afford room for speculation; but it were better, in the mean while, to repeat the experiment again with more delicacy, and on a greater scale.

Compressibility of other Fluids.

The compression of some other fluids was likewise measured in the same way. The contraction, under the weight of an atmosphere, and at the ordinary temperature, amounted, in millionth parts of the entire capacity of the ball, to sixty-six with alcohol, to forty-eight with olive oil, to forty with sea-water, and only to three when mercury was opposed. We may therefore estimate, in round numbers, the modulus of elasticity belonging to those different substances as under:

| | | |
|---|---|---|
| Alcohol . . . . | 580,000 | English feet. |
| Distilled water . . | 700,000 | |
| Olive oil . . . . | 730,000 | |
| Sea-water . . . | 780,000 | |
| And Mercury . . . . | 800,000 | |

In liquids of so distinct a nature, we should have expected a greater diversity in their elastic power; nor is it easy to conceive on what conditions or habitudes that quality actually depends. The elasticity of a body, like its other constitutional properties, may result from the peculiar internal structure, or the arrangement of the integral molecules.

Zimmerman.

Some experiments on the compressibility of water have been since performed with more striking effect, but not equally exempt from all objections. In 1779, Professor Zimmerman of Brunswick printed a short account of some trials made by him and Abich, director of the salt-mines, with a press of a particular construction, consisting of a tight cylinder of very thick brass, with a piston nicely fitted, to be pushed down by means of a long lever, at whose extremity different weights were appended. Rain-water, being introduced into the cavity, was subjected to an enormous pressure, equivalent to that of 313 atmospheres, and had its volume then diminished between one thirty-fifth and one thirty-sixth part. This quantity gives, for the effect of a single incumbent atmosphere, a condensation amounting to seventy-five millionth parts, instead of forty-six, as found by Mr Canton. The excess was, no doubt, owing to the distention of the brass cylinder, which, with all its strength and solidity, would yet partially yield to the action of such prodigious force. This circumstance renders the experiment somewhat unsatisfactory, and the influence of friction must likewise affect the accuracy of the calculation.

The effect of such distention is easily witnessed in the case of glass. If a large bulb of a thermometer be suddenly squeezed between the finger and the thumb, the mercury will start up in the stem perhaps several degrees, and will again sink as quickly after the pressure is removed. To prevent any derangement from communication of heat, the hand may be covered with a thick glove. But the fact can be shown in a less exceptionable way: Let a mercurial thermometer, with a large bulb and a long stem, be first held upright, and then immediately inverted; between these two positions, the column of mercury will descend through a visible space. This apparent change of volume has been hastily supposed by some experimenters to mark the compressibility of mercury, which could not be sensible but under the action of a column of incomparably greater height.

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Bramah's hydraulic Press.

It would be most desirable to institute a new set of observations on the condensation of different substances, by means of Bramah's hydraulic press, which is a far more perfect machine, and scarcely subject at all to the disturbance of friction. Having once ascertained the distention of the metallic cavity from pressure, it would be hence easy to correct all the other results. This mode of experimenting promises also the important advantage of enabling us to determine, with ease, the compressibility of solids themselves. It would only be required, to give those bodies a cylindrical form, nearly adapted to the cavity, and to fill up the interstice with water, or rather with mercury. The contraction which the thin sheet of fluid would undergo, being deducted from the whole contraction, would exhibit the contraction suffered by the solid nucleus.

Celerity of Sound through Water:

From all these investigations, we may gather, that an impulse, or a sonorous tremor, would shoot through a body of fresh-water with the velocity of about 4,475 feet each second, being four times swifter than the ordinary flight of sound in the atmosphere. Through the waters of the ocean, the transmission of sound would be still more rapid, by a seventeenth part. It hence follows, that a violent commotion, excited under that vast mass, might reach from pole to pole in the space of three hours and twenty minutes. The swell of the sea is accordingly always observed to precede the coming storm. The shocks of the famous earthquake at Lisbon, in 1755, were partially felt at very distant points of the ocean, as far even as the West Indies, but after a considerable interval of time.

And through Ice.

Respecting the power of ice to conduct sound, we possess not sufficient data for the solution of the problem. The Danish philosophers are indeed said to have lately performed experiments of this kind on a very extensive scale, along the frozen surface of the Baltic. We are not acquainted with the precise results; but it seems probable, from various analogies, that ice has nearly the same faculty of transmission as water itself. If a heavy blow be struck against any part of the frozen surface of a large pool or lake, a person standing at a wide distance from the spot will feel, under foot, a very sensible tremor, at some considerable time before the noise conveyed through the atmosphere has reached his ear. It is asserted, that the savage tribes who rove on the icy steppes of Tartary can readily distinguish, from afar, the approach of cavalry, by applying their head close to the frozen surface of the ground.

Propagation of Sound through the Atmosphere.

But the proper and ordinary vehicle, of sound is our atmosphere. Aristotle, deriving his information probably from the tenets of the Pythagorean school, seems to have acquired tolerably just notions of the nature of sound and of the theory of harmonics. The language of that philosopher was so much corrupted, however, and disguised by ignorant transcribers, that Galileo, who not only studied music as a science, but practised it as a delightful art, may be fairly allowed to have rediscovered those general doctrines. Mersenne and Kircher afterwards made a variety of most

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ingenious experiments, which, though rather overlooked at the time, tended greatly to extend the science of harmony. But it was reserved for the genius of Newton to sketch out the true theory of sound.

Newton's Theory of the propagation of Sound.

In his *Principia*, he explained the origin of aërial pulses, and, by a fine application of dynamics, conducted with his usual sagacity, he succeeded in calculating their celerity of transmission. The solution which he has given of this intricate problem, is far, however, from being unexceptionable in the form and mode of reasoning. Instead of attempting to embrace all the conditions affecting the problem, in a differential equation, for which, indeed, his fluxionary calculus was not yet so far advanced, he proceeds less boldly, and only arrives at the conclusion, by an indirect process and a sort of compensation of errors. His investigation of the progress of sound through the air, is chiefly drawn from the analogy of the motion of waves along the surface of water. This comparison greatly assists our conceptions, but it fails in a variety of essential points. Newton farther assumed the rising and subsiding of waves to be a reciprocating motion, similar to that of the oscillations of a fluid contained in a wide and long tube, with its ends turned upwards. On this supposition, it was not difficult to prove, that those alternating movements would correspond to the vibrations of a pendulum of half the length of the tube. Transferring the inference, therefore, to the undulations of a fluid, it followed, that the space between two consecutive waves would be described during the sweep of a pendulum having a length equal to this interval. But the conclusion does not very well accord with the phenomena. That a wave travels with a velocity as the square root of its breadth, may be nearly true; and that its reciprocating motions, whatever be the height, are all performed in the same time, is a necessary consequence of the great principle in dynamics first pointed out by Huygens and Hooke,—that when the effort to restore equilibrium is proportioned to the quantity of displacement, the alternations of figure are constantly isochronous. But the velocity of the undulating progression, as calculated from those principles, will not be found to correspond with actual observation. Newton was apparently sensible of this disagreement, and would consider his proposition as only an approximation to the truth, assigning, as the cause of discrepancy, *that the particles of water do not rise and fall perpendicularly, but rather describe arcs of a circle.* The great defect of the hypothesis, however, consisted in supposing all the parts of a wave to rise up and sink together in the same spot. The fact is, that the fore part of a wave is always in the act of ascending, while the hinder part of it is as constantly subsiding; which combined, but contrary, movements, without actually transferring any portion of the water, gives an appearance of progressive advance to the swell.

In extending this theory to the propagation of sound, Newton was, on the whole, more successful. It resulted from his investigation, that the aërial pulses fly uniformly, spreading themselves equally on every side, and with a celerity equal to what would be acquired by a body in falling through half the height of the modulus of the air's elasticity. This modulus, or the altitude of a column of air, of uniform density, and whose pressure would be equivalent to the ordinary elasticity of that fluid, was computed in the first edition of the *Principia*, which came out in 1687, on the supposition that water is 850 times denser than air, mercury $13\frac{1}{2}$ times denser than water, and that the mean height of the barometer is thirty English inches. The modulus of elasticity, or the height of an equiponderant column of air, was therefore estimated at 29,042 feet, which gave 968 feet each second, for the celerity of the transmission of sound through the atmosphere.

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His correction of the Theory.

In the next edition, which did not appear till twenty-six years thereafter, the computation of the modulus was somewhat altered, but certainly not rendered more correct. Assuming the same standard of barometric height as before, and supposing mercury to be $13\frac{2}{3}$ times heavier than water, and water 870 times heavier than air, the modulus would be 29,725 feet, to which the corresponding velocity of sound is 979 feet in the second.

In these successive estimates, there is perhaps betrayed some desire to magnify the result, yet without nearly approaching to the amount of actual observation. Dr Derham had recently determined, from repeated trials made with care, that the ordinary flight of sound is at the rate of 1142 feet each second; and Newton endeavoured, by some very strained hypotheses, to accommodate his calculation to this correct measure. 1. He supposes the particles of air to be perfectly solid spherules, whose diameter is the ninth part of their mutual distance. Sound, being instantaneously communicated through these, would thus have its velocity increased by one-ninth, or 109 feet, or brought up to 1088 feet in the second. 2. He next assumes, that the particles of vapour concealed in the air, and augmenting the common elasticity without partaking of the impression of sound, amount to a tenth part of the whole. This would increase the celerity of the sonorous pulse in the subduplicate ratio of 10 to 11, or as 20 to 21 nearly, and consequently advance the last measure from 1088 to 1142 feet.

Remarks on these Corrections.

But these random and fanciful conjectures hardly require any serious consideration. What may be the size of the ultimate particles of air, or whether they have any sensible magnitude at all, we are utterly without the means of determining. There appears no limit indeed, to the degree of condensation of which the air is capable, but what proceeds from the imperfection of the engines employed for that purpose. Nay, supposing so large a proportion of absolute matter to exist in the composition of our atmosphere, it really would not affect the result, since the transit of sound, as we have shown, is necessarily progressive, even through the most solid substance. To this principle there could be no exception, unless the particles of air were held to be mere atoms, incapable of farther subdivision—in short, without actual magnitude, and therefore bearing no relation whatever to the space in which they float. The second hypothesis advanced, is still more insufficient to rectify the general conclusion. That moisture, in its latent or gaseous form, is united with the air, will be granted; but it by no means constitutes such a notable share of the fluid as Newton has assumed, scarcely

exceeding, at the ordinary temperature, perhaps the five-hundreth part of the whole weight. But this diffuse vapour could not in the least derange the original calculation, for, being always combined with the air, the measure of elasticity assigned by experiment was really that of the compound fluid which forms our atmosphere.

Rectified calculation of the velocity of Sound.

We are now enabled, by the help of more perfect *data*, to rectify the modulus of atmospheric elasticity, or the height of a homogeneous and equiponderant column of the fluid. From the observations made with barometrical measurements, it appears that such a column, exerting a pressure equivalent to the elasticity of the air, has, at the limit of freezing water, an altitude of 26,060 feet, and consequently, that the modulus would, at an ordinary temperature of 62° by Fahrenheit, amount to 27,800 feet. This corrected estimate gives only 943 feet each second for the celerity of sound. And since the elasticity of the medium is exactly proportioned to its density, the result is the same, whatever be the rarefaction or condensation of the air, so long as its temperature continues unaltered. The flight of sound is hence as rapid near the surface as in the higher regions of the atmosphere. It is the conjunction of heat alone that will increase the celerity of transmission, by augmenting the elasticity of the medium without adding to its weight. The acceleration thus produced, must amount to rather more than one foot in the second, for each degree by Fahrenheit's scale. Such a difference ought to be perceptible under the torrid zone.

Rate of transmission through different Gases.

But the rate of the transmission of sound must vary in different gases, after the inverse subduplicate ratio of their densities. Thus, through carbonic gas, the communication of the tremor would be about one third slower than ordinary; but, through the hydrogen gas, which is twelve times more elastic than common air, the flight would very nearly exceed three and a half times the usual rapidity. An admixture of this gas with the atmosphere would, therefore, greatly accelerate the transmission of sound. The joint combination of heat and moisture, by heightening the elasticity of the air, must likewise produce a similar effect.

Experiment in France.

These inferences are confirmed by observation, as far as it extends. The velocity of sound was determined with considerable accuracy, and on a great scale, by Cassini and Maraldi, while employed in conducting the trigonometrical survey of France. During the winter of the years 1738 and 1739, these astronomers repeatedly discharged, at night, when the air was calm, and the temperature uniform, a small piece of ordnance, from their station on Mont-Martre above Paris, and measured the time that elapsed between the flash and the report, as observed from their signal tower at Mont L'hery, at the distance of about eighteen miles. The mean of numerous trials gave 1130 feet, for the velocity of the transmission of sound.

And in America.

About the same time, Condamine, who was sent with the other academicians to ascertain the length of a degree in Peru, took an opportunity of likewise measuring the celerity of sound, at two very different points. He found this was 1175 feet on the sultry plain of Cayenne, and only 1120 feet on the frozen heights of Quito. It was obvious, therefore, that the rarefaction of the air in those lofty regions had in no degree affected the result. Compared with what had been observed in France, the velocity of the aërial pulses was somewhat diminished at Quito, by the prevailing cold, but was, on the other hand, considerably augmented by the excessive heat and moisture which oppress Cayenne.

But the difference, amounting indeed to one-fifth of the whole, between the velocity of sound, as deduced from theory, or determined by actual experiment, still appeared very perplexing. This want of congruity was the more felt, since the Newtonian system of gravitation, after maintaining a long struggle with the adherents of the Cartesian philosophy, had at last obtained the undisputed possession of the Continent. Its triumph was ensured by the admirable dissertations on the subject of tides, transmitted to the Academy of Sciences at Paris, in the year 1740, when our celebrated countryman, Maclaurin, had the honour of sharing the prize with Euler and Daniel Bernoulli. The law of attraction received, indeed, a temporary shock a few years afterwards, from the result of the investigation which Clairaut first gave of the lunar inequalities; but, on resuming his analysis of the problem, and computing the values of the smaller terms of the formula, that great geometer obtained, in 1752, a final product, exactly conformable to the best astronomical observations; and the solidity of the Newtonian system was henceforth placed on the firmest foundation.

It was, therefore, peculiarly desirable to examine likewise the justness of the hydrodynamical conclusions of Newton. The propositions concerning the propagation of sound, were perhaps justly considered as the most obscure part of the whole *Principia*. Some of the first-rate mathematicians abroad, particularly D'Alembert and John Bernoulli, declared their utter inability to comprehend such intricate and disjointed demonstrations. At last, the problem of sonorous pulses was attacked directly and in its full extent, by the late Count Lagrange, whose death, although at a ripe age, will be lamented as a most severe loss to mathematical science. That illustrious geometer shone forth at once like a meteor, and before he had completed his twenty-third year, he gave a rigorous and profound analysis of the propagation of sound through the atmosphere, in the first volume of the Turin Memoirs, which appeared in 1759. "He pointed out some mistakes that even Newton had committed in the reasoning; but mistakes which, by a happy compensation of errors, did not affect essentially the results. Advancing from these discussions, he assigned the dynamical conditions of undulation, which, after the proper limitations, were reduced to an equation involving *partial differences* of the second order. But this refined branch of analysis, invented by D'Alembert and Euler, is still so imperfect, that, in order to integrate the final expression, it had become requisite to omit the higher powers of the differentials. Yet, after all this display of accurate research, and skilful adaptation of symbols, followed by a lax and incomplete calculus, the same conclusion was obtained, as that which Newton had derived chiefly from the force of analogy and sagacity of ob-

Investigation of Lagrange.

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servation; and philosophers were thus obliged to submit, and to content themselves with recording the variance between theory and experiment in regard to the celerity of sound, or with referring that discrepancy to some extraneous influence."—(*Edinb. Rev.* Vol. XV. p. 431.)

M. Poisson, one of those interesting men whose native genius has surmounted all the obstacles of fortune, very lately attempted a more complete analysis of the propagation of sound, in the Papers of the Polytechnic School. The final equation is fuller expressed, and its integration is pushed some few steps farther; but still the result is precisely the same as before. The skill and precaution displayed in framing the conditions of the problem, are afterwards mostly abandoned in the various simplifications adopted to arrive at the conclusion.

Rectification of the theory by Laplace.

A very ingenious and apparently satisfactory method of reconciling theory with observation in the estimate of the transmission of sound, was not long since suggested by the celebrated Count Laplace. If the heat contained in air had, at every state of the density, been united constantly after the same proportion, the elasticity resulting from the infusion of this subtle and highly distensible element would invariably accord with what observation assigns to the compound aërial fluid. But the capacity of air, or its aptitude to retain heat, varies with its internal condition; being increased by rarefaction, and proportionally diminished by condensation. When air is compressed, therefore, it liberates a portion of its heat; and when it undergoes dilatation, it becomes disposed to abstract more heat from the adjoining bodies. Till the equilibrium of heat is again restored, the air will be sensibly warmer after each act of compression, and colder when suffered to dilate. If the shock given to a portion of air, be very sudden and violent, the quantity of heat evolved from it, is profuse and powerful. On this principle, M. Mollet, member of the academy of Lyons, led by some facts noticed by artists who manufactured wind-guns, first constructed, in 1804, the curious instrument for producing fire, by the rapid condensation of air confined in a tube. But such evolution of heat must besides augment the elasticity of the air, as the contrary abstraction of it will, in a like degree, diminish that force. At every sudden alteration of density, therefore, a new power is infused, which had not entered into the ordinary and undisturbed estimate of the air's elasticity. Consequently, from this consideration alone, the aërial pulses must shoot with some greater celerity than calculation assigns, because the particles of air which are suddenly condensed have their elasticity farther augmented by the portion of heat evolved, while the corresponding particles, which are simultaneously dilated, have their disposition to contract likewise increased, by the momentary prevalence of cold.

Examination of this correction.

The principle advanced by Laplace must therefore have a real operation, tending to reconcile the calculated velocity of sound with that which is deduced from experiment. The only question is, how far its influence could actually extend? But, according to the formula given in Leslie's *Elements of Geometry*, p. 495, a condensation, equal to the 90th part of the volume of air, would occasion the extrication of one degree of heat by Fahrenheit's scale. Now, since each degree of heat enlarges the bulk, or augments the elasticity of the air by the 450th part, it follows, that the heat, extricated by sudden impulse, will communicate to the air a momentary additional spring, amounting to one-fifth of the whole elastic force. Wherefore the celerity of sound would, by that influence, be increased in the subduplicate ratio of five to six, or nearly as 21 to 23; which gives an addition of only 90 feet each second to the whole quantity, bringing it up to 1033 feet. The correction is thus insufficient, not amounting to half of the discrepancy which it was its object to reconcile.

It may be suspected, therefore, that some inaccuracy or omission infects the investigation itself. Till the integral calculus has arrived at much greater perfection, it will often be requisite for the analyst, in the solution of dynamical problems, to descend from his elevation, and seek to simplify the differential expressions, by a sober and judicious application of the principles of physics. "Imagine a string of particles, or physical points, A, B, C, D, E, F, &c. in a state of rest, or mutual balance. If A were pushed nearer to B, and then suddenly abandoned, it would recoil with a motion exactly similar to the oscillation of a pendulum. The time of this relapse might easily be determined from a comparison of the force of gravity with that of elasticity, or from the number of particles contained in a column of equipoise. The minute interval between the adjacent particles, being now divided by the duration of each fit of contraction, will give the velocity with which the vibratory influence shoots along the chain of communication. This simple investigation leads still to the same result as before. But it proceeds on assumptions which are evidently incorrect; for it supposes the pulses to follow each other in accurate succession, every contraction terminating as the next begins. Since the particles, however, do not exist in a state of insulation, while B repels A, it must likewise press against C, and C, in its turn, must gradually affect D. Before the contraction of A and B is completed, that of B and C is therefore partially performed; and this anticipated influence may even extend to the remoter particles. Nor is the system of mutual action at all materially disturbed by such anticipations. Each pulsation is performed in the same way as if it were quite detached, only the succeeding one is partly accomplished before the regular period of its commencement. The velocity of aërial undulations is in this way much accelerated." (*Edinb. Rev.* Vol. XV. p. 433). Each successive movement among the particles may be viewed as produced by a force not regularly decreasing, but partaking of the uniformity which obtains in projection. Hence the velocity of sound is intermediate between that derived from theory and that with which air would rush into a vacuum. But the arithmetical mean between 943 and 1334 feet is $1138\frac{1}{2}$, and the geometrical is $1121\frac{1}{2}$ feet; neither of which differs much from 1130 feet, the quantity determined by actual experiment.

Modifications required in the Theory of Sound.

After the last correction, however, proposed by M. Laplace, for adjusting theory with observation relative to the celerity of the transmission of sound, the difference will not perhaps be regarded such as

longer to present any serious obstacle; especially when the conincidence appears closer than what generally attends the theoretical deductions concerning the motions of fluids. The remaining difficulties affecting the subject refer chiefly to the way in which the aërial pulses are propagated, and the modifications which they are afterwards capable of receiving.

Duration and strength of Pulsation.

1. No sensation is ever excited unless the impression made upon our organs be repeated or continued during a certain short space of time. On this principle depends the whole success of the juggler, who contrives to change the situation of the various objects before us with a rapidity exceeding the ordinary exercise of sight or touch. A brand whirled swiftly round the head, gives all the appearance of a circle of fire; and if one presses very hard an ivory ball between his fingers, he will seem still to feel it, for several instants after it has been withdrawn. To excite the sensation of sound, it is requisite that the aërial pulses should have a certain force and duration. According to some observations, the ear is not affected at all, unless the tremulous impulse communicated to the tympanum lasts during the tenth part of a second. Every pulsation of a more transient kind is lost absolutely and completely to our organ of hearing.

On the other hand, the impression of sound is not prolonged beyond the time of its actual production. If it were otherwise, indeed, all sounds would degenerate into indistinct noises, and articulate discourse, which distinguishes man from the lower animals, and constitutes the charm of social life, would have been utterly impossible. This fact, so obvious, and yet so important, shows indisputably, that the propagation of sonorous pulses through the atmosphere is not, in all its circumstances, analogous to the succession of waves on the surface of water. These undulations continue long afterwards to rise and spread from the centre of their production. The pulsations of the air, no doubt, likewise survive their excitement; but such of them as succeed the first impulsion, must not have the force and character of those which are directly shot through the fluid. What is the precise discrimination between these different pulses, we are not enabled from mere theory to determine. But such a distinction must undoubtedly exist, otherwise indeed all discourse would continue to fill the ear with a monotonous hum, or an indistinct muttering. It would be difficult to institute conclusive experiments on this subject, yet collateral researches might be devised which could not fail to guide our inquiry.

Concentration in a particular Direction.

2. But another defect in the analogy between waves and sonorous pulses, is, that the latter, without affecting to spread equally, are capable of acquiring a superior force or tendency in some given direction. Certain unconfined sounds, indeed, are diffused uniformly on every side. Thus, the noise of the explosion of a powder-mill is heard, and often dreadfully felt, at a great distance all round the scene of disaster. But the report of a cannon, though audible in every direction, appears invariably loudest in the quarter to which the engine is pointed. On this principle, a seaman, when he seeks to be heard more audibly, or at a greater distance, is accustomed, if no other help occurs, to apply his spread hands on each side of his mouth, and thus check or diminish the waste of sound by its lateral dispersion. For the same reason, the bent and projecting circular piece annexed to the farther end of a speaking-trumpet is of most decided use, in assisting to give direction to the flight of the aërial pulses.

Accumulation along Barriers.

3. The theory of undulatory movements furnishes some elucidation, but no adequate explication of the augmented effect of sound in the direction of a lateral barrier. The extension of such an obstacle might appear to check merely the spread and consequent attenuation of the sonorous pulses; but the great accumulation of impulse always occurs, on either side, at the extremity of the advancing wave. By what system of interior forces this effect is produced, it would be difficult satisfactorily to explain. Yet we perceive something analogous, in the swell which runs along the margin of a pool, and in the billow which, flowing from the open sea, heaves against the sides of a projecting mole.

It is hence, that sound is made to sweep with such intensity over the smooth surface of a long wall or of an extended gallery. An elliptical figure, though of manifest advantage, is not really essential to a whispering gallery; for the point of sonorous concentration is found beyond the true catoptrical focus, and much nearer to the wall. A fact of the same kind is well ascertained—that sounds are always heard the most audibly, and at the greatest distance, in a level open country, or still better, on the smooth surface of a vast lake, or of the ocean itself. The roaring of the cannon in certain naval engagements, has been noticed at points so very remote from the scene of action, as might seem, if not perfectly authenticated, to be altogether incredible. On the other hand again, sound is enfeebled and dissipated sooner in alpine regions. Thus, the traveller, roving at some height above a valley, descries, with uncommon clearness, perhaps a huntsman on the brow of the opposite mountain, and while he watches every flash, yet can he scarcely hear the report of the fowling-piece.

On a similar principle, we would explain the operation of the ear-trumpet, which affords such relief to one of the most cheerless maladies that can afflict humanity. The wide mouth of that instrument, it is well known, is turned to catch the stream of sound; the extent of pulsation is gradually contracted as the tide advances; and the same quantity of impulse being probably maintained, the vibratory energy is intensely accumulated at the narrow extremity, where it strikes the cavity of the ear. A trumpet of this form might in many cases be found very advantageous not only for remedying the defects of the organ of hearing, but for assisting the observer to collect feeble and distant sounds. Even an umbrella held close behind the head, with its concavity fronting the sonorous pulses, will, it has been alleged, sensibly heighten their impression.

Reflexion modified.

4. To explain legitimately the reflexion of sound, would require some modifications in the theory of atmospheric undulation. Each obstructing point is certainly not the centre of a new system of pulses, for, in many cases, this would occasion unutterable confusion. Nor can the excitement of sound be sup-

posed to dart in straight lines, or to perform the same accurate reflexion as the rays of light. In fact, neither is smoothness nor exact regularity of surface required for the production of an echo. A range of buildings, a row of tall trees, a ridge of rocks, or a chain of heights, will, in certain positions, reflect sound with clear and audible effect. It follows, therefore, that the reflexion must be formed, not at the immediate surface of those obstacles, which could occasion only an irregular dispersion, but at some boundary at a small distance, and running parallel to the mean direction of the whole barrier. We may conceive the tide of sound accumulating where it stops, and investing the opposite surface like an atmosphere, till a repulsion is exerted, which again rolls it back. What seems to constitute the perfection of an echo, is that the sum of the distances of every point of the reflecting surface from the person who speaks, and from him who listens, should be the same. When this disposition obtains, all the reflected sounds must reach the ear in due succession, without being intermingled or confused.

We may observe, that echoes are often confounded with the mere *resonance* occasioned by vibrations excited among the obstacles themselves. In a large empty room, with its naked floor, and walls, and benches, the voice quickly throws the whole into a tremulous commotion, and seems drowned in the ringing prolonged sound which is produced; nor does this unpleasant effect cease, until the spectators have occupied the benches, filled the hall, and obstructed by their weight the vibration of the floor. What is called the *deadening* of sound, consists in merely checking or preventing the disturbance of extraneous tremor. For this purpose, the floor is covered with carpets, and the walls lined with wainscotting or hangings. Such barriers, we have seen, would not, by their yielding quality, blunt or obstruct the formation of echoes. Their only effect is, to muffle the elastic surfaces which they cover.

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impet.

The performance of the speaking-trumpet has generally been referred to the concentrated reflexion of sound. Some authors have carried the hypothesis even so far as to investigate, from mathematical principles, the best figure of that instrument. Much labour and great ingenuity have been utterly wasted in this fruitless attempt. Kircher proposed the tube to be shaped like a truncated parabolic conoid, the mouth-piece occupying the focus; and he concludes that all the *rays of sound* would, by reflexion from such a surface, be sent forward exactly in parallel lines. Other philosophers have imagined, from a fanciful analogy to the property of ivory balls, that the figure described by the revolution of the logarithmic curve about its absciss, would be the most proper for the speaking-trumpet. M. Lambert, of the Berlin academy, whose genius and originality were both of the first order, has given a solution still different. But it would be idle to recite the various attempts which have ended in no practical result.

eslie.

The true physical explication of the speaking-trumpet was first given, as far as we know, in the course of an incidental remark by Professor Leslie, in his *Experimental Inquiry into the Nature and Propagation of Heat.* "In the case of articulate sounds (says he,) the confining of the air does not affect the pitch of voice, but it augments the degree of intonation. The lateral flow being checked, that fugacious medium receives a more condensed and vigorous impulsion. As the breath then escapes more slowly from the mouth, it waits and bears a fuller stroke from the organs of speech. But the speaking-trumpet is only an extension of the same principle. Its performance does certainly not depend upon any supposed repercussion of sound; repeated echoes might divide, but could not augment the quantity of impulse. In reality, however, neither the shape of the instrument, nor the kind of material of which it is made, seems to be of much consequence. Nor can we admit, that the speaking-trumpet possesses any peculiar power of collecting sound in one direction; for it is audible distinctly on all sides, and is perhaps not much louder in front, comparatively, than the simple unassisted voice. The tube, by its length and narrowness, detains the efflux of air, and has the same effect as if it diminished the volubility of that fluid, or increased its density. The organs of articulation strike with concentrated force; and the pulses, so vigorously thus excited, are, from the reflected form of the aperture, finally enabled to escape, and to spread themselves along the atmosphere. To speak through a trumpet costs a very sensible effort, and soon fatigues and exhausts a person. This observation singularly confirms the justness of the theory which I have now brought forward."



Hassenfratz.

Nearly about the same time, this theory was confirmed by some ingenious experiments made by M. Hassenfratz, at Paris. His method of estimating the power of a speaking-trumpet consisted in fixing a small watch in the mouth-piece, and observing at what distance the beats ceased to be distinctly audible. He found that the effects were precisely the same with a trumpet of tinned iron, whether used in its naked form, or after it was tightly bound with linen, to prevent any vibration of the metal. Nor could there be the smallest reflection of sound from the internal surface of the tube, for the beating of the watch was heard exactly at the same distance after the whole of the inside had been lined with woollen cloth. These simple experiments prove decisively, that the performance of the speaking-trumpet depends principally on the intenser pulsation which is excited in the column of confined air. In the same way, sound is prodigiously augmented in a long narrow passage. If a musket be fixed within the gallery of a mine, the explosion heard in a remote corner, will have the loudness and character of thunder.

Sound of musketry.

The progressive motion of sound furnishes the explication of various remarkable facts and striking phenomena. Thus, to a person standing at some distance, and directly in front of a long file of musketry, the general discharge will appear as a single collected sound, the numerous reports all reaching his ear nearly at the same instant. But one stationed at the end of the line will hear only a prolonged rolling noise, not unlike a running fire; because the distinct sounds, from the different distances which they have to travel, will arrive in a continued succession. Hence, likewise, the tremendous rumbling

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noise of distant thunder, which is not produced, as many have supposed, by the repetition of echoes. In certain situations, indeed, and particularly in hilly tracts, echoes may, no doubt, contribute to augment the general effect; but their ordinary influence seems to be really insignificant, since it should cause the same modification of sound in the explosion of a cannon, which is essentially different, however, from the muttering and crash of thunder. This lengthened and varied noise must yet be the production of a moment. The rapidity of lightning surpasses conception, and the prolongation of the sound which follows it is owing to the various distances of the chain of points which emit the sonorous impressions. The electrical influence darts with immeasurable swiftness from cloud to cloud, till perhaps it strikes at last into the ground. But, from every point of this tortuous path, distinct pulses of sound are transmitted, which consequently reach the ear at very different intervals. Sometimes they arrive intermingled, and give the sensation of a violent crash; at other times they seem suspended, and form a sort of pause. It would not be very difficult in any case to imagine the zig-zag track which the lightning must pursue, in order to produce a given protracted rumbling noise. The duration of each peal of thunder will evidently be shortened if it chance to shoot athwart; but must continue the longest, when it runs in the line of the spectator. As the distance of thunder is estimated by allowing somewhat more than a mile for every five seconds that elapse between the flash and the beginning of the report, so the space traversed by the lightning, if its general direction were known, might be computed by the same rule, from the endurance of the sound.

Noise of Thunder.

Musical Note.

We will not enter at present on that branch of acoustics which treats of the doctrine of harmony; but a few scattered remarks may trace the general outline of the subject. A musical note, far from being only a repetition of the same simple sound, should be considered as the conjunction of subordinate sounds reiterated at proportional intervals. The sweetness of this compound effect or tone, appears to depend on the frequent recurrence of interior unison. The secondary sounds which naturally and invariably accompany the fundamental note are repeated only two, three, or four times faster; nor does the science of music admit of any proportions but what arise from the limited combinations of those very simple numbers. Harmony again is created by an artificial union of different notes, analogous to the natural composition of tone.

Vibrating Instruments.

All tones are produced by the regular vibrations, either of solid substances or of confined air itself. Strings of gut or of metal are most generally used; but small plates or pillars of wood, of glass, or even of stone, will answer the same purpose, forming the singular instrument called *staccata* or *harmonica*. In these cases, the quality of the vibrations depends on the joint influence of a variety of circumstances; not only on the length of the fibres, but on their thickness their elasticity, their density, and the degree of tension to which they are subjected. The motion of a musical stretched chord was first investigated by the very ingenious Dr Brook Taylor, though his solution has been since proved to be incomplete. At the same time, in fact, that the whole chord oscillates, its simpler portions, the half, the third and the fourth of its length, actually perform a set of intermediate vibrations.

Wind Instruments.

Wind instruments produce their effect by the vibrations of a column of air confined at one end, and either open or shut at the other. These vibrations are determined merely by the length of the sounding column. Yet, interior and subordinate vibrations are found to co-exist with the fundamental one. The whole column spontaneously divides itself into portions equal to the half, the third or the fourth of its longitudinal extent. We shall more easily conceive these longitudinal vibrations, by observing the contractions and expansions of a long and very elastic string, to the end of which a ball is attached. A spiral spring shows still better the repeated stretching and recoil. If struck suddenly at the one end, it will exhibit not only a total vibration, but likewise partial ones, winding vermicularly along the chain of elastic rings.

But when the air is struck with uncommon force, the subordinate vibrations become predominant, and yield the clearest and loudest tones. This we perceive in the dying sounds of a bell, which rise by one or two octaves, and expire in the shrillest note. On such a very narrow foundation—on the variable force with which it is blown—rests the whole performance of the bugle-horn, whose compass is extremely small, consisting only of the simplest notes. In other wind-instruments, the several notes are caused by the different lengths of the tube, or by the various positions of the holes made in its side.

Tones produced by the burning of hydrogen Gas.

The longitudinal vibrations of a column of air contained within a tube open at both ends, are powerfully excited, and very loud and clear tones produced, by the inflammation of a streamlet of hydrogen gas. This curious experiment was made first in Germany, and appears, indeed, to have been scarcely known, or at least noticed in other countries. Yet it is most easily performed, and will be considered as amusing, if not instructive. A phial, having a long narrow glass pipe fitted to its neck, being partly filled with dilute sulphuric acid, a few bits of zinc are dropt into the liquid. As the decomposition of the water embodied with the acid now proceeds, the hydrogen gas, thus generated, flows regularly from the aperture, and is capable of catching fire, and of burning for some considerable time, with a small yet steady round flame. This very simple arrangement, frequently styled the philosophic lamp, is in reality of the same nature with the combination, on a large scale, of the gas lights. A glass tube being passed over the exit-pipe, the burning speck at its point instantly shoots into an elongated flame, and creates a continued, sharp and brilliant, musical sound. This effect is not owing to any vibrations of the tube itself, for it is no wise altered by tying a handkerchief tightly about the glass, or even by substituting a cylinder of paper. The tremor excited in the column of air is, therefore, the sole cause of the incessant tone, which only varies by a change in the place of the flame, or a partial obstruction applied at the end of the tube. But still it is not easy to

conceive how the mere burning of a jet of hydrogen gas within the cavity, should produce such powerful vibrations. The exciting force must necessarily act by starts, and not uniformly. The length of the flame might seem to prove, that the hydrogen gas is not consumed or converted into aqueous vapour, as fast as it issues from the aperture. A jet of it catches instantaneous fire, but is immediately followed by another, the succession of inflamed portions being so rapid as entirely to escape the keenness of sight. The column of air contained within the tube would thus be agitated by a series of incessant strokes or sudden expansions.

The singular fact now described had occurred incidentally to the writer of this article, in the course of his earliest experiments; and he has often thought since, that, on the same principle, an organ might be constructed, which would have a very curious and pleasing effect. A vertical motion of the glass tubes, and the partial shutting or opening their upper ends, would occasion a considerable variety of notes. By passing the hydrogen gas over different metals, the flame would be made to assume various colours. The apparatus might work by a spontaneous mechanism; and while the eye was gratified by the display of rich and vivid tints, the ear would be charmed with strains of new and melodious symphony.

See in this Supplement, the articles Echo, Harmonics, Sound, Vibration, and Trumpet. (D.)

ADAM (Alexander) Rector of the High School Edinburgh, and author of several valuable works connected with Roman literature, was born June 24th 1741, on a small farm which his father rented, not far from Forres, in Morayshire. He does not appear to have received any powerful direction to literary pursuits, either from the attainments of his parents, or the ability of the parochial schoolmaster; but is referable to a class of men, of which Scotland can produce a very honourable list, whom the secret workings of a naturally active mind have raised above the level of their associates, and urged on to distinction and usefulness under the severest pressure of difficulties. The gentle treatment of an old schoolmistress first taught him to like his book, and this propensity induced his parents to consent that he should learn Latin. To the imperfect instruction which he received at the parish school, he joined indefatigable study at home, notwithstanding the scanty means and poor accommodation of his father's house. Before he was sixteen, he had read the whole of Livy, in a copy of the small Elzevir edition, which he had borrowed from a neighbouring clergyman; omitting for the present all such passages as his own sagacity and Cole's dictionary did not enable him to construe. It was before day-break, during the mornings of winter, and by the light of splinters of bog-wood dug out of an adjoining moss, that he prosecuted the perusal of this difficult classic; for, as the whole family were collected round the only fire in the evening, he was prevented by the noise from reading with any advantage; and the day-light was spent at school.

In the autumn of 1757, he was a competitor for one of those bursaries, or small exhibitions, which are given by the university of Aberdeen to young men who distinguish themselves for their classical attainments; but as the prize was awarded to the best written exercises, and as Adam, with all his reading, had not yet been accustomed to write, he was foiled by some youth who had been more fortunate in his means of instruction. About the same time Mr Watson, a relation of his mother's, and one of the ministers of the Canongate, sent him a tardy invitation to come to Edinburgh, "provided he was prepared to endure every hardship for a season;"—a condition not likely to appal one who yet knew nothing of life but its hardships. The interest of Mr Watson procured him free admission to the lectures of the different professors, and as he had now also access to books in the College Library, his literary ardour made him submit with cheerfulness to the greatest personal privations. Eighteen months of assiduous application enabled him to repair the defects of his early tuition, and to obtain, after a comparative trial of candidates, the head mastership of the foundation known by the name of Watson's Hospital. At this period he was only nineteen, on which account the governors of the institution limited the appointment to half a year; but his steadiness and ability speedily removed their scruples. After holding the situation for three years, he was induced, by the prospect of having more leisure for the prosecution of his studies, to resign it, and become private tutor to the son of Mr Kincaid, a wealthy citizen, and afterwards Lord Provost, of Edinburgh; and it was in consequence of this connection that he was afterwards raised to the office for which he was so eminently qualified. He taught in the High School, for the first time, in April 1765, as substitute for Mr Matheson the rector; in consequence of whose growing infirmities, an arrangement was made, by which he retired on a small annuity, to be paid from the profits of the class; and Mr Adam was confirmed in the rectorship on the 8th June 1768.

From this period, the history of his life is little more than the history of his professional labours, and of his literary productions. No sooner was he invested with the office, than he gave himself up with entire devotion to the business of his class, and the pursuits connected with it. For forty years his day was divided with singular regularity between the public duties of teaching, and that unwearied research and industry in private, which enabled him, amidst the incessant occupation of a High School master's life, to give to the world such a number of accurate and laborious compilations. So entirely did these objects of public utility engross his mind, that he mixed but little with society, and considered every moment as lost that was not dedicated in some way or other to the improvement of youth. Few men certainly could adopt, with more truth and propriety, the language of Horace, both with regard to his own feelings, and the objects on which he was occupied:

> —— mihi tarda fluunt ingrataque tempora, quæ spem
> Consiliumque morantur agendi gnaviter id, quod
> Æquè pauperibus prodest, locupletibus æquè,
> Æquè, neglectum, pueris senibusque nocebit.
>
> *Epist.* I. 1. 23.

The rector's *class*, which, in the High School, is the most advanced of five, consisted of no more than be-

tween thirty and forty boys, when Dr Adam was appointed. His celebrity as a classical teacher, joined to the progress of the country in wealth and population, continued to increase this number up to the year of his death. His class-list for that year contained 167 names,—the largest number that had ever been collected in one class, and what is remarkable, equal to the amount of the whole five classes during the year when he first taught in the school.

He performed an essential service to the literature of his country, by introducing, in his own class, an additional hour of teaching, for Greek and Geography; neither of which branches seems to have been contemplated in the original formation of the school. The introduction of Greek, which he effected a year or two after his election, was regarded by some professors of the University as a dangerous innovation, and an unwarrantable encroachment on the province of the Greek chair; and the measure was accordingly resisted, (though, it is satisfactory to think, unsuccessfully,) by the united efforts of the Senatus Academicus, in a petition and representation to the Town-council, drawn up and proposed by the celebrated Principal of the University, Dr Robertson. This happened in 1772.

It is not possible for a man of principle and ordinary affections, to be occupied in training a large portion of the youth of his country to knowledge and virtue, without feeling a deep responsibility, and a paramount interest in their progress and well-doing. That such were Dr Adam's feelings is proved, not less by the whole tenor of his life, than by his mode of conducting the business of his class; by the free scope and decided support he gave to talent, particularly when the possessor of it was poor and friendless; by the tender concern with which he followed his pupils into life; and by a test, not the least unequivocal, the enthusiastic attachment and veneration which they entertain for his memory. In his class-room, his manner, while it imposed respect, was kindly and conciliating. He was fond of relieving the irksomeness of continued attention by narrating curious facts and amusing anecdotes. In the latter part of his life, he was perhaps too often the hero of his own tale; but there was something amiable even in this weakness, which arose from the vanity of having done much good, and was totally unmixed with any alloy of selfishness.

Dr Adam's first publication was his *Grammar*, which appeared in 1772. He had two principal objects in compiling it:—to combine the study of English and Latin grammar, so that they might mutually illustrate each other; and to supersede the preposterous method of teaching Latin by a grammar composed in that language, and of overloading the memory with rules in Latin hexameters, for almost every fact, and every anomaly in its grammatical structure. The change he proposed, reasonable as it was, could not be effected without running counter to confirmed prejudices, and interfering with established books. Although, therefore, the grammar met with the approbation of some eminently good judges, particularly of Bishop Lowth, the author had no sooner adopted it in his own class, and recommended it to others, than a host of enemies rose up against him, and he was involved in much altercation and vexatious hostility with the town-council, and the four under-masters. Dr George Stewart, then professor of humanity, was related to Ruddiman, whose grammar Dr Adam's was intended to supersede; and to this cause may be traced the commencement of the determined opposition that was long made to any change. In these squabbles, the acrimony displayed by some of his adversaries, now and then altered the natural suavity of Dr Adam's temper; and his high notions of independence, and contempt of presumptuous ignorance, led him perhaps to neglect too much those easy arts of conciliation, which enable a man, without the slightest compromise of his integrity, "to win his way by yielding to the tide."

His work on *Roman Antiquities* was published in 1791, and has contributed, more than any of his other productions, to give him a name as a classical scholar. The vast variety of matter, the minuteness and accuracy of the details, the number and fidelity of the references, the constant bearing the work has upon the classics, and the light it throws on them at every step, were soon perceived and appreciated over the whole island. These solid excellencies abundantly compensate for a certain air of heaviness, and the absence of the lighter graces of interesting style and manner. His reader follows him as he would do a faithful guide, through a strange and difficult country, with a feeling of perfect assurance that he will arrive at the end of his journey, if not by the pleasantest road, at least by the most direct and secure. The *Roman Antiquities* is now adopted as a class-book in many of the English schools, and, even in those where the influence of custom opposes innovation, it is found in every master's library, and recommended by him to his advanced pupils for private reading and reference.

In 1794, he published his *Summary of Geography and History*, in one thick 8vo volume of 900 pages, which had grown in his hands to this size from a small treatise on the same subject, printed, for the use of his pupils, in 1784. The object of this work was to connect the study of the classics with that of general knowledge; and it accordingly contains a curious compound of interesting matter, unwieldy as a school-book, and not always arranged in the most luminous or engaging order; but valuable to the young student, for its succinct account of the first principles of astronomical, mathematical, and physical science, and for the mass it contains of geographical and historical information, especially with regard to the fabulous ages of antiquity.

His *Classical Biography*, published in 1800, is the least in request of all his works; a circumstance owing, perhaps, to the more comprehensive and popular plan of Lempriere's *Classical Dictionary*. It exhibits, however, ample proofs of well-directed industry; and in the number and unfailing accuracy of the references, furnishes an excellent index to the best sources of information, even where the book itself may be thought meagre and scanty.

His last work was his *Latin Dictionary*, which appeared in 1805, printed, like every other production of his pen, in the most unassuming form, and with the

utmost anxiety to condense the greatest quantity of useful knowledge into the smallest bulk, and afford it to the student at the cheapest rate. It was intended chiefly for the use of schools, and to be followed by a larger work, containing copious illustrations of every word in the language. The character which he had acquired by his former works for patient research and correct detail, stamped a high and deserved authority on this book. The clear account of the different meanings of words, the explanation of idioms, and happy translation of difficult passages, which abound, particularly in the latter half, are admirably well adapted to remove the difficulties of the younger student, and render the work, notwithstanding the modesty of its pretensions, equally valuable to the more advanced. It is much to be regretted, he did not live to complete his larger work, on the extended scale on which the latter part of the small one is executed. He had proceeded as far as the word *Comburo*, with a plenitude of illustration that would have made the work a treasure of Latinity, when he was seized in school with an apoplectic affection,—occasioned, perhaps, by the intenseness of his application, and the small portion of sleep he allowed himself; certainly not by his mode of living, which was simple and abstemious to an extreme degree. He lingered five days under the disease. Amidst the wanderings of mind that accompanied it, he was constantly reverting to the business of the class, and addressing his boys; and in the last hour of his life, as he fancied himself examining on the lesson of the day, he stopped short, and said, "But it grows dark, you may go;" and almost immediately expired. He died on the 18th of December 1809, at the age of sixty-eight.

The magistrates of Edinburgh, whose predecessors had not always been alive to his merits, shewed their respect for his memory by a public funeral. A short time before his death, he was solicited, by some of his old pupils, to sit to Mr Raeburn for his portrait, which was executed in the best style of that eminent artist, and placed, as a memorial of their gratitude and respect, in the library of the High School.

He was twice married; first in 1775, to Miss Munro, eldest daughter of the Minister of Kinloss, by whom he had several children, the last of whom died within a few days of his father; and, in 1789, to Miss Cosser, daughter of Mr Cosser, Comptroller of Excise, who, with two daughters and a son, are still alive. (F.)



ADANSON (MICHAEL) a celebrated naturalist, was descended from a Scotish family which had at the Revolution attached itself to the fortunes of the House of Stuart; and was born the 7th of April 1727, at Aix in Provence, where his father was in the service of M. de Vintimille, then Archbishop of that province. On the translation of this prelate to the archbishopric of Paris about the year 1730, the elder Adanson also repaired thither, accompanied by his infant family of five children, all of whom were provided for by their father's patron. A small canonry fell to the lot of our future naturalist; the revenue of which defrayed the expences of his education at the college of Plessis. While there, he was distinguished for great quickness of apprehension, strength of memory, and mental ardour; but his genius took no particular bent, until he received a microscope from the celebrated Tuberville Needham, who happened to be present at one of the public examinations, and was struck with admiration of his talents and acquirements. From the moment that young Adanson received this donation, to the last hour of his life, he persevered with a zeal almost unexampled in the observation and study of nature.

On leaving college, his youthful ardour was well employed in the cabinets of Reaumur and Bernard de Jassieu, as well as in the "Jardin des Plantes." Such was his zeal, that he repeated the instructions of the professors to such of his fellow students as could not advance with a rapidity equal to his own; and before he had completed his nineteenth year, he had actually described (for his own improvement) four thousand species of the three kingdoms of nature. In this way he soon exhausted the rich stores of accumulated knowledge in Europe; and having obtained a small appointment in the colony of Senegal, he resigned his canonry, and embarked on the 20th of December 1748, for Africa.

The motives which decided the choice of Senegal as the scene of his observations, are recorded by himself, and are too remarkably indicative of his ardent thirst of knowledge, not to be noticed. "It was," says he, in a memorandum found after his death, "of all European establishments, the most difficult to penetrate, the most hot, the most unhealthy, the most dangerous in every respect, and consequently the least known to naturalists."

His ardour remained unabated during the five years that he remained in Africa; in which period he collected and described an immense number of animals and plants;—delineated maps of the country, and made astronomical observations;—prepared grammars and dictionaries of the languages spoken on the banks of the Senegal;—kept meteorological registers;—composed a detailed account of all the plants of the country;—and collected specimens of every object of commerce. M. Cuvier mentions that he had seen the produce and results of all these multifarious and laborious exertions.

The situation in which Adanson was placed, was admirably adapted to foster originality of genius; but it was also attended with every disadvantage that can arise from a want of comparison and rivalry. The collision of kindred intellects generally diminishes an overweening conceit; whilst entire seclusion from literary society as generally increases the presumption of genius, and renders errors familiar by long uncorrected repetition. To these causes, and to the secluded life which he continued to lead even after his return to Europe, may probably be traced some of the peculiar features of Adanson's character. Thus he chose to distinguish himself by a new system of orthography; and, instead of a simple and convenient nomenclature, he employed a set of arbitrary terms, whose etymology could not be traced, and the synonyms to which he rarely condescended to point out. He was opinionative in no small degree; and his vanity and self-confidence too often led him to overlook, or to

Adanson.

undervalue, the labours of those who were engaged in the same field of inquiry.

About the period of Adanson's return to Europe, which took place in 1754, natural history had undergone a very important revolution, from the valuable, though widely differing, labours of Buffon and Linnæus. The one, giving loose to his imagination, pursued a path as seductive as beautiful; the other, entering with minute discrimination into every department, furnished a text-book to philosophers; leaving the splendid paintings of his eloquent rival to those who delight rather in brilliancy of colouring, than in the chaste portraiture of nature. Both of these distinguished men, from too closely confining themselves to their individual views, appear to have, in a great measure, overlooked a most interesting branch of their subject, viz. the general relations of all beings, from which is deduced the division of them into families; which division is founded on their peculiar characters. This had formed an important branch of Adanson's solitary reflections, and the boldness with which he developed his views soon attracted the admiration of naturalists. To appreciate thoroughly the value of his labours, it will be necessary to exhibit a rapid sketch of the general principles which influence *natural* arrangements, and the particular views entertained by Adanson.

Every organized being is to be considered as an assemblage of parts, which, by reciprocal actions, produce certain effects. Between all of these parts a mutual dependence subsists, and no modification can be effected in any one member of the series without sensibly affecting all the others in a greater or less degree. It is obvious, that there can only be a certain number of possible combinations; which may be divided into two great classes, the primary and the subordinate.

The first step towards the knowledge of these combinations would be an accurate acquaintance with all the actually existing organs. If this were attained, and if a complete view of all possible combinations were deduced, every organized being would be allotted to a determinate place, according to its organs; and there would be a correct systematic arrangement of all organic nature; every relation, every property, would be reducible to general laws; every function might be demonstrated; and natural history would become a precise science. Such, however, is only the ideal perfection at which we aim in attempting natural methods, to which we cannot expect the rapid advance fancied by some visionary theorists, but to which a steady perseverance, unclouded by preconceived prejudices, will ultimately enable us to approach.

The most direct means of calculating the effects of the before-mentioned modifications would be to determine the function and the influence of each organ. In this way, the great divisions might be made according to the most important organs, and the inferior would be naturally founded on the relations of the less important organs. A scale would thus be established, not less correct as regarding the order of nature, than if it had been formed subsequently to a full examination of all her works. This principle of classification has been named by some philosophers "*the subordination of characters.*" It is rational and philosophical; but its application presupposes an advancement in science far beyond that which existed at the period when Adanson commenced his labours. Accordingly, he adopted a more experimental method—that of a complete comparison of species; and the mode of applying his scheme is abundantly ingenious, and entirely his own.

Adanson.

He founded his classification of all known organized beings on the consideration of each individual organ. As each organ gave birth to new relations, so he established a corresponding number of arbitrary arrangements. Those beings possessing the greatest number of similar organs were referred to one great division, and the relationship was considered more remote in proportion to the dissimilarity of organs.

The chief defect of this method consists in presupposing a knowledge, not less difficult of attainment than the former,—of species and their organization. It gives, however, distinct ideas of the degree of affinity subsisting between organized beings, independent of all physiological science. Of this "*universal method,*" as he called it, Adanson gave some account in an essay contained in his Treatise on Shells, published at the end of his "*Voyage au Senegal.*"

Until the appearance of this work, the animals inhabiting shells had been much neglected. On this branch of his subject, our author exercised his wonted zeal, while his methodical distribution, founded on not less than twenty of the partial classifications already alluded to, is decidedly superior to that of any of his predecessors. Like every first attempt, however, it had its imperfections, and these arose from not having examined the anatomical structure of the animals; from which cause he omitted, in his arrangement of the class of *Mollusca*, all *molluscous* animals without shells.

His original plan was to have published the whole of the observations made during his residence at Senegal, in eight volumes; but being deterred by the difficulties attending so extensive a publication, he abandoned the scheme, and applied himself entirely to his "*Families of Plants,*" which he published in 1763. In this he found the application of his general principle not less advantageous than in his preceding works.

The distribution of plants into *natural* families has attracted the notice of botanists since the middle of the seventeenth century. Bernard de Jussieu, the friend and instructor of Adanson, bestowed much attention on this subject; but, dissatisfied with his success, has left no other memorial of his labours than the arrangement which he introduced in the gardens of *Trianon* in 1758. Prompted by his own bold genius, as well as by the example of so distinguished a friend, Adanson undertook the task; and although he fell into errors which had been avoided by Jussieu, he executed it, upon the whole, with consummate ability. In the preface to this work, he gave an elaborate account of the history of botany; and here it is not difficult to perceive that one of his chief objects was to insinuate his own claims to be placed at the head of scientific botanists.

In 1774, (eleven years after the appearance of his *Families of Plants,*) he submitted to the consideration of the Academy of Sciences an immense work,

containing what may be called the *universal application of his universal method;* for it extended to all known beings and substances, whether in the heavens or on the earth. Twenty-seven large volumes of manuscript were employed in displaying the general relations of all these matters, and their distribution. One hundred and fifty volumes more were occupied with the alphabetical arrangement of 40,000 species. There was also a vocabulary, which contained 200,000 words, with their explanations; and the whole was closed by a number of detached memoirs, 40,000 figures, and 30,000 specimens of the three kingdoms of nature. The committee of the academy, to which the inspection of this enormous mass had been intrusted, warmly recommended to Adanson to separate and publish all that was peculiarly his own, leaving out what was merely compilation; but he obstinately rejected this reasonable advice; by which means science has been deprived of many essays, which, if we may judge from others which he at different times gave to the world, would have possessed great merit.

In the midst of his scientific ardour, Adanson devoted much of his attention to a subject, on which his feelings had probably been powerfully awakened during his residence in Senegal:—we need scarcely name the slave trade. Anxious to contribute to the comforts of Europe, as well as to the security of Africa, he addressed a memoir to the minister, in which he attempted to demonstrate that Senegal was well fitted for the production of all the valuable produce of the West Indian Archipelago, and that, by suitable encouragement, free negroes might be induced to engage in the cultivation of the soil. This proposition received no encouragement, either from the minister or the French African Company; and, as his mistaken notions of patriotism led him to reject all overtures from the friends of the abolition in England, the details of his plan still remain unknown to the world.

Of Adanson's public life little farther remains to be said; for, after his rejection of the proffered counsel of the academicians, he seems to have pursued his philosophic career in silent and unobtrusive retirement. Engaged in such occupations, it might have been supposed that he would have been exempted from the evils of that terrible revolution which has been productive of so many calamities to his country and to Europe. But the case was very different. As he had devoted his life to science for its own sake, he had never made it the means of acquiring wealth; and having no patrimony from his ancestors, his only fortune consisted of pensions, the reward of his labours in Senegal, and the price of the specimens furnished by him to the royal cabinet. With an injustice and illiberality distinctive of revolutionary Frenchmen, the Constituent Assembly deprived this harmless man, who was known only as an ornament to science, of what he had so hardly earned. A trifling pension from the Academy still remained, and was sufficient for his limited wants; but on the dissolution of that respectable body by the fanatical republicans, this his last resource was also annihilated. When the revolutionary frenzy had subsided, and science again received the homage of Frenchmen, the reproachful poverty of this veteran sage was at length relieved from the public funds; and the founders of the Institute were proud to enrol his name in the catalogue of its members. But his life was now drawing near to its close. He died, after many months of severe suffering, on the 3d of August 1806.

Adanson was never married. In his will, he requested, as the only decoration of his grave, a garland of flowers gathered from the fifty-eight families which he had established;—"A touching, though transitory image," says Cuvier, "of the more durable monument which he has erected to himself in his works." His zeal for science, his unwearied industry, and his talents as a philosophical observer, are conspicuous in all his writings. The serenity of his temper, and the unaffected goodness of his heart, endeared him to the few who knew him intimately. On the other hand, it must be admitted, that, from early habits, he trusted too exclusively to his own talents, and would never deign to examine the discoveries of others; so that he persisted in a thousand times refuted errors, with as much pertinacity as he did in the most unquestionable truths of science. Cuvier relates a remarkable instance of his contempt for every thing that did not fall within the scope of his own observations. Although he had bestowed much care on the subject of *mosses*, yet, in 1800, he was ignorant, not only of the discoveries, but even of the very existence of Hedwig. But, though his vanity was great, it was not accompanied with any malignant feelings; and, notwithstanding his misfortunes, he was never heard to accuse any person of having contributed to inflict them.

His most important works are, 1. his *Voyage to Senegal*, and 2. his *Families of Plants*. To the former some essays already noticed were subjoined; and various others were published, at different times, in the *Transactions of the Academy of Sciences*. The volumes for the years 1759, and 1761, contain his Observations upon the *Taret*, (a species of shell-fish exceedingly destructive to vessels,) and his Account of the *Baobab*, an enormous African tree, now known under the name of *Adansonia*. The volume for 1769 contains an interesting discussion by Adanson, upon the origin of the varieties of cultivated plants; and in those for 1773 and 1779 will be found his valuable observations on gum-bearing trees. In the Transactions of 1767 he gave an account of the *Oscillatoria Adansonii*, which he considered a self-moving vegetable; but which ought, according to some observations of M. Vaucher, to be ranked as a zoophyte. Besides these Essays, Adanson contributed several valuable articles in natural history, to the earlier part of the Supplement to the first *Encyclopédie;* and he is also supposed to have been the author of an essay on the *Electricity of the Tourmaline*, (Paris, 1757), which bears the name of the Duke of Noya Caraffa. See *Eloge Historique de M. Adanson*, par Cuvier.—*Mem. Mathem. et Physiques, de l'Inst. National*, Tom. VII. (G.)

ADELUNG (John Christopher) a very eminent German grammarian, philologer, and general scholar, was born at Spantekow in Pomerania, on the 30th of August 1734. He acquired his elementary instruction at the public school of Anclam, and that

of Closterbergen, near Magdeburgh, and completed his academical education at the university of Halle. In the year 1759, he was appointed professor at the Gymnasium of Erfurt, but relinquished this situation two years after, and went to reside, in a private capacity, at Leipsic, where he continued to devote himself, for a long period, to the cultivation of letters, and particularly to those extensive and laborious philological researches which proved so useful to the language and literature of his native country. In 1787, he received the appointment of principal librarian to the Elector of Saxony at Dresden, with the honorary title of Aulic Counsellor. Here he continued to reside during the remainder of his useful life, discharging, with diligence and integrity, the duties of his situation, and prosecuting his laborious studies to the last, with indefatigable industry and unabated zeal. He died at Dresden, on the 10th of September 1806, at the age of seventy-two.

The life of a mere scholar is generally destitute of interest, and that of Adelung, which was spent entirely in literary seclusion, presents no variety of incident to the pen of the biographer. Of his private character and habits few memorials have been preserved; but in these few he is represented as a man of an amiable disposition. He was never married. His constitution, which was remarkably robust, rendered him capable of the most intense and unremitted application to study, insomuch that, down to the period of his death, he is said to have devoted fourteen hours of every day to literary labour. He was a lover of good cheer, and spared neither pains nor expence in procuring a variety of foreign wines, of which his cellar, which he facetiously denominated his *Bibliotheca Selectissima*, is said to have contained no less than forty different kinds. His manners were easy and affable, and the habitual cheerfulness of his disposition rendered his society most acceptable to a numerous circle of friends.

The works of Adelung are very voluminous, and there is not one of these, perhaps, which does not exhibit some proofs of the genius, industry, and erudition of the author. But although his pen was usefully employed upon a variety of subjects in different departments of literature and science, it is to his philological labours that he is principally indebted for his great reputation; and no man ever devoted himself with more zeal and assiduity, or with greater success, to the improvement of his native language.

In a country which is subdivided into so many distinct sovereign states, possessing no common political centre, and no national institution whose authority could command deference in matters of taste; in a country whose indigenous literature was but of recent growth, and where the dialect of the people was held in contempt at the several courts,—it was no easy task for a single writer to undertake to fix the standard of a language which had branched out into a variety of idioms, depending, in a great measure, upon principles altogether arbitrary. Adelung effected as much, in this respect, as could well be accomplished by the persevering labours of an individual. By means of his excellent grammars, dictionary, and various works on German style, he contributed greatly towards rectifying the orthography, refining the idiom, and fixing the standard of his native tongue. Of all the different dialects, he gave a decided preference to that of the Margraviate of Misnia, in upper Saxony, and positively rejected every thing that was contrary to the phraseology in use among the best society of that province, and in the writings of those authors whom it had produced. In adopting this narrow principle, he is generally thought to have been too fastidious. The dialect of Misnia was undoubtedly the richest, as it was the earliest cultivated of any in Germany; but Adelung probably went too far in restraining the language within the limits of this single idiom, to the exclusion of others, from which it might, and really has, acquired additional richness, flexibility, and force.

His dictionary of the German language is generally allowed to be superior to our English dictionary by Dr Johnson. It is eminently so in its etymologies; and is, perhaps, upon the whole, the best work of the kind of which any nation can boast. Indeed, the patient spirit of investigation which Adelung possessed in so remarkable a degree, together with his intimate knowledge of the ancient history and progressive revolutions of the different dialects, from which the modern German is derived, rendered him peculiarly qualified for the successful performance of the duties of a lexicographer.

It would greatly exceed our limits, and lead us into far too wide a field, were we to attempt to present our readers with an analysis of the several productions of this voluminous author; but we should do injustice to his memory, were we to pass over, in total silence, his last very learned work, entitled, *Mithridates, or a General History of Languages, with the Lord's Prayer, as a specimen, in nearly five hundred languages and dialects*. The hint of this work appears to have been taken from a publication, with a similar title, published by the celebrated Conrad Gessner, in 1555; but the plan of Adelung is much more extensive. Unfortunately, he did not live to finish what he had undertaken; but the work has been continued, with much ability, by that eminent philologer, Professor Vater, formerly of Halle, now of Koningsberg. The first volume, which contains the Asiatic languages, was published immediately after the death of Adelung; the second, which comprehends the European dialects, was published by Professor Vater, in 1809; the first part of the third volume, which is almost entirely the work of the last-mentioned scholar, appeared in 1812. This third and last volume is to contain the languages of Africa and America, and will be enriched with some very valuable materials, communicated to the editor by Baron de Humboldt.

Many of the works of Adelung were published anonymously; but we believe the following list will be found to be complete and correct.

1. *Neue Schaubühne der Vorfallenden Staats-Kriegs und Friedenshändel.* New Theatre of Historical and Political Events. Erfurt, 1759-61. 8vo.
2. *Neues Lehrgebäude der Diplomatik, aus dem Franz. übersetzt, und mit Anmerk. versehen.* New System of Diplomacy, translated from the French, with Notes. Vols. I. II. III. Erfurt, 1760.
3. *Neue Denkwürdigkeiten der gegenwärtigen Ges-*

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*chichte von Europa.* New Memoirs of the present History of Europe. 2 vols. 1761. 8vo.

4. *Geschichte der Streitigkeiten zwischen Dänemark und den Herzögen von Holstein-Gottorp.* History of the Disputes between Denmark and the Dukes of Holstein-Gottorp. Frankf. Leipsic, 1762-4.
5. *Pragmatische Staatsgeschichte Europens von dem Ableben Kaiser Karls des 6ten an.* Pragmatic History of Europe. from the death of the Emperor Charles VI. Vols. I.—IX. Gotha, 1762.
6. *Auserlesene Staatsbriefe.* Select Letters on Affairs of State. 2 vols. Gotha, 1763-4. 8vo.
7. *Vollständige Geschichte der Schiffahrten nach den Südländern.* A complete History of the Voyages undertaken to Australasia, translated from the French of the President De Brosse, with Notes. Halle, 1767. 4to.
8. *Mineralogische Belustigungen.* Mineralogical Recreations. Vols. I.—VIII. Copenhagen and Leipsic, 1767.
9. *Einleitung zur allgemeinen Weltgeschichte.* Introduction to Universal History. 2 vols. Berlin, 1767. The first volume by Prof. Franzer.
10. *Werke des Philosophen von Sans Souci.* The Works of the Philosopher of *Sans Souci*, translated from the French. Erfurt, 1768.
11. *Staatsmagazin, 14 Stücke.* Fourteen Numbers of the Political Magazine. Leipsic, 1768.
12. *Geschichte der Schiffahrten und Versuche, welche zur Entdeckung des nordöstlichen Wegs nach Japan und China unternommen worden.* History of Voyages undertaken with a view to discover the North-east Passage to Japan and China. Halle, 1768. 4to.
13. *Versuch einer neuen Geschichte des Jesuiter ordens.* Essay towards a new History of the Order of the Jesuits. Vols. I. and II. Berlin and Halle, 1769 and 1770. 8vo.
14. *Natürliche und bürgerliche Geschichte von Californien.* Natural and Civil History of California, translated from the English. 3 vols. Lemgo, 1769-70. 4to
15. *Unterweisung in den vornehmsten Künsten und Wissenschaften, zum Nutzen der niedern Schulen.* Elements of Instruction in the principal Arts and Sciences, for the use of the lower Schools. Frankfort and Leipsic, 1771. 8vo. Reprinted in 1775, 1777, and 1789.
16. *Glossarium Manuale ad Scriptores mediæ et infimæ Latinitatis, ex magnis Glossariis Caroli du Fresne Domini Ducange et Carpentarii, in compendium redactum, multisque verbis et dicendi formulis auctum.* Tomi V. Halle, 1772-78. This is a useful abridgment of the Dictionary of Ducange, with Charpentier's additions.
17. *Versuch eines vollständigen grammatisch-kritischen Wörterbuchs der Hoch Teutschen Mundart, mit beständiger Vergleichung der übrigen Mundarten, besonders aber der Ober Teutschen.* Essay towards a complete grammatical and critical Dictionary of the High German Dialect, with a constant comparison of the other dialects, particularly the Upper German. 1774-86. 4to. 5 vols.
18. *Wallerius Chemie.* Waller's Chemistry, translated from the Latin.
19. *Allgemeines Verzeichniss neuer Bücher mit kurzen Anmerkungen, nebst einem gelehrten Anzeiger auf das Iahr* 1776. A general Catalogue of new Books, with short Notes, and an Index, for the year 1776. Leipsic, 1776. 8vo. Also the 2d, 3d, 4th, 5th, and 6th annual series of the same periodical publication, down to 1781.
20. *Schauplatz des Baierischen Erbfolge Kreigs, u. s. w.* Theatre of the War of the Bavarian Succession, &c. 6 Numbers, 4to. Leipsic, 1778, 1780.
21. *Militärisches Taschenbuch auf das Iahr* 1780. Military Pocket-book for the Year 1780. Leipsic. 12mo.
22. *J. Williams Ursprung, Wachsthum und Gegenwärtiger Zustand der Nordischen Reiche.* J. Williams's Origin, Progress, and Present State of the Northern Governments, translated and corrected from the English. 2 vols. 8vo. Leipsic, 1779-81.
23. *Kurzer Begriff menschlicher Kenntnisse und Fertigkeiten, so fern sie auf Erwerbung des Unterhalts, auf Vergnügen, auf Wissenschaft, und auf Regierung der Gesellschaft abzielen.* A short Compendium of Arts and Sciences, so far as they have for their object to satisfy the wants, to increase the pleasures of life, and to regulate the government of society. 4 vols. 8vo. Leipsic, 1778-81. 2d Edit. 1783-9.
24. *Ueber die Geschichte der Teutschen Sprache, über Teutsche Mundarten und Teutsche Sprachlehre.* On the History of the German Language, on German Dialects, and German Grammar. *Ibid.* 1781. 8vo.
25. *Ueber den Ursprung der Sprache und den Bau der Wörter.* On the Origin and Structure of Language. *Ibid.* 1781. 8vo.
26. *Teutsche Sprachlehre, zum Gebrauch der Schulen in den Königl. Preuss. Landen.* German Grammar, for the use of the schools in his Prussian Majesty's dominions. Berlin, 1781. 2d Edit. improved and enlarged, 1792. This grammar has been frequently reprinted.
27. *Auszug aus der Teutschen Sprachlehre für Schulen.* Abridgment of the German Grammar for Schools. 1781. 8vo.
28. *Lehrgebäude der Teutschen Sprache, zur Erläuterung der Teutschen Sprachlehre für Schulen.* Theory of the German Language, to illustrate the German Grammar for Schools.
29. *Tindals und Sr More Anmerkungen zu Rapins Geschichte von England.* Tindal's and More's Notes to Rapin's Hist. of Engl. Translated from the English.
30. *Versuch einer Geschichte der Cultur des Menschlichen Geschlechts.* Essay towards an History of the Civilization of the Human Race. 1782. 8vo.
31. *Leipziger Politische Zeitung und Allerley.* Leipsic Political Journal and Miscellanies.
32. *Neues Grammatisch-kritisches Wörterbuch der Englischen Sprache, für die Teutschen.* New Grammatical and Critical Dictionary of the English Language, for Germans. Leipsic, 1783. 8vo.
33. *Beyträge zur Bürgerlichen Geschichte, zur Geschichte der Cultur, zur Naturgeschichte, Naturlehre, und dem Feldbaue ; aus den Schriften der Akademie der Wissenschaften zu Brüssel.* Contribu-

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tions to Civil History, to the History of Culture, to Natural History, Natural Philosophy, and Agriculture; from the Transactions of the Academy of Sciences at Brussels. 1 vol. 8vo. Leipsic, 1783.

34. *Fortsetzungen und Ergänzungen zu Christ. Gottl. Iöchers allgemeinem Gelehrten Lexico.* Continuations and Additions to Christ. Gottl. Iöcher's general Dictionary of Literature. These additions by Adelung extend from letter A to K. Leipsic, 1784. 4to. 2 vols.

35. *Ueber den Teutschen Styl.* On German Style. 3 vols. Berlin, 1785. 8vo.

36. *Neue Leipziger Gelehrte Zeitung.* The New Leipsic Literary Journal: this work was conducted by Adelung in 1785, and following years.

37. *Grundsätze der Teutschen Orthographie.* Principles of German Orthography. Leipsic, 1782. 8vo.

38. *Geschichte der Menschlichen Narrheit, oder Lebens beschreibungen berühmter Schwarzkünstler, Goldmacher, Teufelsbanner, Zeichen und Liniendeuter, Schwärmer, Wahrsager und anderer philosophischer Unholden.* An History of Human Folly: or Lives of the most celebrated Necromancers, Alchemists, Conjurers, Astrologers, Soothsayers, &c. 7 vols. Leipsic, 1785-87-89.

39. *Geschichte der Philosophie für Liebhaber.* An History of Philosophy, for Amateurs. 3 vols. 1786-87.

40. *Vollständige Anweisung zur Teutschen Orthographie, nebst einem kleinen Wörterbuche für die Aussprache, Orthographie, Biegung und Ableitung.* Complete System of German Orthography, with a small Dictionary for Pronunciation, Orthography, Derivation, &c. 2 vols. Leipsic, 1786. 2d Edit. 1790.

41. *Jacob Püterich von Reicherzhausen, ein Kleiner Beytrag zur Geschichte der Teustchen Dichtkunst im Schwäbischen Zeitalter.* Jacob Püterich, &c. a small Contribution to the History of German Poetry in the age of the Suabian Minstrels. Leipsic, 1788. 4to.

42. *Auszug aus dem Grammatisch-kritischen Wörterbuch der Hohen Teutschen Mundart.* Abridgment of the Grammatical and Critical Dictionary of the High German Dialect. 1 vol. Leipsic, 1793. 2 vols. 8vo. 1795.

43. *Mithridates, oder Allgemeine Sprachenkunde.* Mithridates, or a General History of Languages, with the Lord's Prayer, as a specimen, in nearly five hundred Languages and Dialects. Berlin. Vol. I. 1806; Vol. II. 1809; Vol. III. Part 1. 1812. This great work was left by Adelung in an unfinished state; but, as already mentioned, it has been continned by that able philologer, Professor Vater of Koningsberg, to whom the public is indebted for an excellent Hebrew Grammar.

It is observed by Mad. de Stael, that the English are much better acquainted than the French with the literature of Germany; but we have met with very few possessed of any knowledge of the works of this learned and celebrated writer; and, with the exception of one or two of his smaller essays, none of them, we believe, has ever been translated into the language of this country. In the above list, there are more than one work which might probably be published with advantage in the English tongue. (H.)

Adhesion.

ADEN, a city on the Arabian coast, to the east of the straits of Babelmandel, the position of which only is mentioned, and that not very accurately, in the body of the work. It is situated in latitude 12° 50′ north, and longitude 45° 10′ east. According to the Arabians, it derives its name from Aden, the son of Saba and grandson of Abraham. Be this as it may, it was once the most flourishing city of Arabia, though it now presents little more than a heap of ruins surrounded with miserable huts. But it is nevertheless a place of considerable consequence on that coast, from the superiority of its harbour, and its other advantages for trade. It is accessible at all times of the year; and from it a constant intercourse may be maintained with the coast of Africa. Coffee of the best quality, and all the other articles which enter into the commerce of the Red-Sea may be procured at this port. In particular, it is the chief mart for the gums brought over from the north eastern districts of Africa; on which account this drug may be procured here at a cheaper rate than at Mocha. The English traders are much in favour at Aden.—See Salt's *Voyage to Abyssinia*, and Milburn's *Oriental Commerce*.

ADHESION, a term chiefly used to denote the force with which the surface of a solid remains attached to the surface of a liquid, after they have been brought into contact. Suppose a polished glass plate to be suspended horizontally from one extremity of a balance, and to be exactly counterpoised by weights put into the opposite scale, if we bring this plate in contact with the surface of a quantity of mercury, we shall find that a certain additional weight must be placed in the opposite scale, in order to separate the glass from the mercury. The force which kept the two bodies in contact is called *adhesion*. Three sets of experiments on this subject have been published by different philosophers.

Dr Brook Taylor in a paper *on magnetism*, inserted in the Philosophical Transactions for 1721, describes the result of his trials to determine the weight necessary to separate fir-boards of different sizes from the surface of water. The result of his experiments was,—that the weight necessary is proportional to the surface of the fir-board to be raised.

In the year 1773, Guyton-Morveau ascertained experimentally the force of adhesion of eleven different metals to mercury. The metals which he employed were pure. The surface of each was an inch (French) in diameter, and polished. The following table exhibits the weight in French grains, necessary to separate each metal from the mercury.

| | |
|---|---|
| Gold | 446 |
| Silver | 429 |
| Tin | 418 |
| Lead | 397 |
| Bismuth | 372 |
| Platinum | 282 |
| Zinc | 204 |
| Copper | 142 |
| Antimony | 126 |
| Iron | 115 |
| Cobalt | 8 |

M. Morveau ascertained likewise, that the adhesive force is not diminished by removing the pressure of the air.

A great number of experiments on the same subject were made at a still later period, by Mr Achard of Berlin. He measured the force of adhesion between various substances and water. He found, that when the temperature was increased, the adhesion proportionally diminished. He even attempted to determine the diminution occasioned by the elevation of temperature, amounting to a single degree of the thermometer; and gives us a formula denoting that diminution. But it is not necessary to enter into any details respecting his experiments here, for a reason that will appear immediately.

Besides these three philosophers, many others have examined the rise of liquids in capillary tubes, a phenomenon which is nothing else than a peculiar case of adhesion; though we cannot with propriety treat of it here. Laplace published a dissertation on the subject in the year 1805, in which he has given us an historical detail, which however is far from accurate. His reasoning appears to us in general correct; though several very plain propositions are rather obscured than elucidated by his mathematical demonstrations.

When we make experiments on the adhesion of solids to liquids, and endeavour to ascertain the force requisite to separate them from each other, two cases may occur. The solid body may separate from the liquid, *dry;* or its surface may be covered with a thin coating of the liquid which it retains. If a surface of tallow be placed in contact with water, and separated from it by weights successively introduced into the opposite scale, we shall find, after the separation has taken place, that the surface of the tallow is *dry*, or that it has not carried along with it a thin coating of the water. But when we employ a fir-board as Dr Brook Taylor did in his experiments, and as Mr Achard did in many of his, the case is very different. We shall find the whole surface of the board thoroughly *wetted;* that is to say, a thin film of the liquid remains adhering to the wood. Now, it is only the first of these two cases that can be considered as exhibiting the true force of adhesion. In the second case, it is not the solid which separates from the liquid; but one portion of the liquid which separates from the other. Such experiments therefore really shew the force of cohesion between the particles of the liquid; not the force of adhesion between the solid and the liquid. Now, as the experiments of Brook Taylor and Achard belong all to this last case, it is obvious that they cannot be considered as experiments on adhesion. We must therefore leave them out of our consideration at present. The cohesion of the particles of liquids is well known to diminish as the temperature increases; till at a certain temperature this cohesion disappears altogether, and the liquids assume the state of elastic fluids, the particles of which repel each other. Hence, the reason why, in Achard's experiments, the adhesive force diminished as the temperature increased.

Adhesion is obviously an attractive force, by which the two surfaces are kept in contact. It must evidently increase as the surfaces adhering, because the number of adhering particles increase in the same ratio. This force is insensible, when the two surfaces are at any perceptible distance from one another; so that it acts only at insensible distances. From Morveau's experiments it appears, that it differs very much in intensity when different solids are made to adhere to the same liquid. Thus gold adheres to mercury, with a force more than twice as great as zinc does, and almost fifty-six times as great as cobalt does. Now these two properties, namely, acting only at insensible distances, and varying in intensity in different bodies, characterize that peculiar force known by the name of *chemical affinity*. But there is one particular in which chemical affinity appears at first sight to differ from adhesion. Chemical affinity is confined to the ultimate particles or atoms of bodies; whereas, adhesion takes place between surfaces of any size whatever.

But, if we consider that these surfaces consist each of a congeries of atoms united into a large mass by the force of cohesion; that adhesion is not sensible at any perceptible distance, however great the extent of surfaces may be; and that its strength increases in proportion to the surfaces—if we consider these phenomena, we shall find reason to conclude, that adhesion is a force which acts only between the atoms or integrant particles of bodies. It is therefore merely a case of *chemical affinity*.

The phenomena of adhesion depend upon the strength of affinity between the adhering bodies. If the affinity be weak, the two surfaces will separate by a small force applied, and the solid will retain no impression of the liquid whatever. This happens when cobalt is brought in contact with mercury, or tallow with water. If the affinity be strong, a considerable force will be requisite to separate the two surfaces. This is the case when gold or silver is brought in contact with mercury. So great is the affinity indeed in these cases, that if the adhesion continue for a short time, a combination actually takes place between the two metals. In that case the gold comes away white, or coated over with a film of mercury; the experiment is no longer an example of the force of adhesion between mercury and gold, but exhibits the cohesive force of the particles of mercury to each other. We have even found that this holds with platinum, though it be a metal which has a much weaker affinity for mercury than gold has. If a clean surface of platinum be kept for some time in contact with that of mercury, a very evident amalgamation takes place.

When a surface of wood, marble or metal, comes in contact with water, on removing it we find that surface moist; that is to say, it has carried with it a thin film of water. This shews us, that the adhesive force of water, or the affinity of water to these different bodies, is greater than the cohesive force of the particles of water for each other. Yet this force is not sufficiently strong to produce a chemical combination between the respective bodies. When a surface of sugar or common salt comes in contact with water, this surface is not merely wetted. If the contact be continued for a sufficient time the solid loses its cohesion, and is dissolved by the liquid. This is a complicated case. The water by capillary attraction insinuates itself through the pores of the sugar. The

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minute crystals of sugar are deprived of their cohesion to each other by this intervening liquid. Being separated from each other, they gradually dissolve or enter into a chemical combination with the water. (J.)

ADMIRAL. Though neither this nor the immediately following articles have been wholly omitted in the body of the work, we have thought it proper to treat them anew, and with more correct detail, in this place; it being our intention, that these Supplemental Volumes shall exhibit a full and accurate view of all that concerns the constitution, government, and efficiency of the British navy. Of the rank of Admiral there are three degrees—Admiral, Vice-Admiral, Rear-Admiral. Each of those degrees consists of three divisions, which are distinguished by as many different colours or flags; hence all admirals assume the common title of *flag-officers*, and take rank and command in the following order:

Admirals of the Red, of the White, of the Blue Squadrons, bearing their respective flags at the main-top-gallant-mast head: Vice-Admirals of the Red, of the White, of the Blue Squadrons, bearing their respective flags at the fore-top-gallant-mast head: Rear-Admirals of the Red, of the White, of the Blue Squadrons, bearing their respective flags at the mizen-top-gallant-mast head.

It may be remarked, that for a century nearly we had no Admiral of the Red squadron; that flag, according to a vulgar error, having been taken from us by the Dutch in one of those arduous struggles for naval superiority which that nation was once able to maintain against the naval power of England. But the fact is, the red flag was laid aside on the union of the two crowns of England and Scotland, when the Union flag was adopted in its place, and usually hoisted by the Admiral commanding in chief. The red flag, however, has recently been revived, on an occasion worthy of the event; namely, on the promotion of naval officers which took place in November 1805, in consequence of the memorable victory before Trafalgar. See article NAVY in this Supplement.

ADMIRAL OF THE FLEET, is a mere honorary distinction, which gives no command, but an increase of half-pay, his being three guineas a-day, and that of an Admiral two guineas. It is sometimes conferred, but not always, on the senior Admiral on the list of naval officers, being held at present by his Royal Highness the Duke of Clarence. If the Admiral of the fleet should happen to serve afloat, he is authorized to carry the union flag at the main-top-gallant-mast head, which was the case when the Duke of Clarence escorted Louis XVIII. across the Channel, to take possession of the throne of France.

The comparative rank which flag-officers hold with officers in the army has been settled as follows by his Majesty's order in council:

The Admiral and Commander-in-chief of the fleet has the rank of a Field-marshal in the army. Admirals with flags at the main take rank with Generals of horse and foot. Vice-admirals with Lieutenant-generals. Rear-admirals with Major-generals. Commodores with broad pendants with Brigadier-generals. See NAVY.

ADMIRAL, THE LORD HIGH OF ENGLAND. An ancient officer of high rank in the state, in whom not only the government of the navy is vested, but who, long before any regular navy existed in England, presided over a sovereign court, with authority to hear and determine all causes relating to the sea, and to take cognizance of all offences committed thereon.

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There can be little doubt of the Asiatic origin of the name given to this officer, which does not appear to have been known in the languages of Europe before the time of the holy wars. *Amir*, in Arabic, is a chief or commander of forces; it is the same word as the *ameer* of the peninsula of India, (as *ameer ul omrah*, the chief of lords or princes,) and the *emir* of the Turks or Saracens, who had, and still have, their *emir or ameer'l dureea*, commander of the sea; *amir'l asker dureea*, commander of the naval armament. The incorporation of the article with the noun appears, we believe, for the first time in the annals of Eutychius, patriarch of Alexandria, in the tenth century, who calls the Caliph Omar *Amirol mumumim*, seu, *Imperator fidilium*. Spelman says, "In regno Saracenorum quatuor pretores statuit, qui *Admiralli* vocabantur." The *d* is evidently impertinent, and is omitted by the French, who say *Amiral*. The Spanish write *Almiranté*; the Portuguese the same. Milton would seem to have been aware of the origin of the word, when he speaks of "the mast of some great Ammiral." It is obvious, then, that the supposed derivations of ἁλμυρὸς from the Greek, *aumer* from the French, and *aen mereal* from the Saxon, are fanciful and unauthorized etymologies.

The period of time about which this officer first makes his appearance in the governments of European nations, corroborates the supposition of its having been adopted in imitation of the Mediterranean powers, at the return of the Christian heroes from the holy wars. According to Moreri, Florent de Varenne, in the year 1270, was the first Admiral known in France; but by the most approved writers of that nation, the title was unknown till, in 1284, Enguerrand de Coussy was constituted Admiral. The first Admiral by name that we know of in England was W. de Leybourne, who was appointed to that office by Edward I. in the year 1286, under the title of *Admiral de la mer du roy d'Angleterre*. Mariana, in his *History of Spain*, says that Don Sancho, having resolved to make war on the barbarians, (Moors,) prepared a great fleet; and as the Genoese were at that time very powerful by sea, and experienced and dexterous sailors, he sent to Genoa to invite, with great offers, Benito Zacharias into his service; that he accepted those offers, and brought with him twelve ships; that the king named him his Admiral, *(Almiranté,)* and conferred on him the office for a limited time. This happened in the year 1284. Several Portuguese authors observe, that their office of *Almiranté* was derived from the Genoese, who had it from the Sicilians, and these from the Saracens; and it appears from Souza's *Historia Geneologica da Caza Real*, that, in 1322, Micer Manuel Piçagow was invited from Genoa into Portugal, and appointed to the office of *Almiranté*, with a salary of three thousand pounds *(livras)* a-year, and certain lands, &c., on condition that he should furnish, on his part, twenty men of Genoa, all experienced in sea affairs, and qualified to be *alcaidis* (captains) and *arraises* (masters)

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of ships; all of which terms, *almiranté*, *alcaidi*, and *arrais*, are obviously of Arabic derivation.

Edward I., who began his reign in 1272, went to the Holy Land, and visited Sicily on his return. He must therefore have had an opportunity of informing himself concerning the military and naval science of the various countries bordering on the Mediterranean —an opportunity which so able and warlike a prince would not neglect; but whether the title and office of Admiral existed in England before his time, as some are inclined to think, or whether W. de Leybourne was first created to that office in 1286, as before mentioned, we believe there is no authentic record to enable us to decide. Supposing him, however, to be the first, Edward may either have adopted the office and title from the Genoese, or the Sicilians, or the Spaniards, or the French; or even had it directly from the Saracens, against whom he had fought, and with whom he had afterwards much amicable intercourse. It would seem, however, that the office was, in Edward's time, merely honorary; for that monarch, in 1307, orders the Lord Mayor of London, at his peril and without delay, to provide a good ship, well equipped, to carry his pavilions and tents; and, in the same year, another order is addressed to the *Vicecomes Kantiæ*, to provide, for immediate passage across the seas, "tot et tales pontes et claias," as the constable of Dover Castle should demand; without one word being mentioned of the admiral. (Rymer, Vol. III. p. 32.)

From the 34th Edward II. we have a regular and uninterrupted succession of Admirals. In that year he appointed Edward Charles Admiral of the North, from the mouth of the river Thames northward, and Gervase Allard Admiral of the West, from the mouth of the Thames westward; and these two Admirals of the North and the West were continued down to the 34th Edward III. when John de Beauchamp, Lord Warden of the Cinque Ports, constable of the Tower of London, and of the Castle of Dover, was constituted *High Admiral of England*; but nine years afterwards, the office was again divided into north and west, and so continued until the 10th Richard II. when Richard, son of Alain Earl of Arundel, was appointed Admiral of England. Two years after this, it was again divided as before; and in the fifteenth year of the same reign, Edward Earl of Rutland and Cork, afterwards Duke of Albemarle, was constituted *High Admiral of the North and West*; and after him the Marquis of Dorset, and Earl of Somerset, son of John of Gaunt, Duke of Lancaster; then Percy Earl of Winchester next succeeded to the same title, which once more was dropped in the 2d of Henry IV. and divided as before. But in the sixth of the same reign, the office of Admiral of England became permanently vested in one person. In the 14th Henry VI. John Holland Duke of Exeter was created Admiral of England, Ireland, and Aquitain, for life; and in the third year of Edward VI. John Dudley Earl of Warwick was constituted High Admiral of England, Ireland, Wales, Calais, Bologne, the marches of the same, Normandy, Gascony, and Aquitain, also Captain-general of the navy and seas of the king, &c. In the 27th Elizabeth, Charles Lord Howard had all the aforesaid titles, with the addition of Captain-general of the navy and seas of the said kingdoms.

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On the 20th November 1632, the office of High Admiral was, for the first time, put in commission, all the great officers of state being the commissioners. During the Commonwealth, a committee of parliament managed the affairs of the Admiralty. At the Restoration, in 1660, his Royal Highness James Duke of York was constituted *Lord High Admiral of England*. The commission was revoked on the 22d May 1684, and King Charles II. held the Admiralty in his own hands, and managed it by the great officers of his Privy-council until his death. He took this occasion of reserving for his own use all the droits and perquisites claimed by the Lord High Admiral. King James II. declared himself in council *Lord High Admiral and Lord General*; and he managed the affairs of the Admiralty and navy by Mr Secretary Pepys all the time of his reign. In the 1st William and Mary, the Admiralty was again put in commission. In the 6th Anne, (1707,) his Royal Highness George Prince of Denmark was appointed *High Admiral of Great Britain*, (in consequence of the union of the two crowns,) with a council to assist him; and at his death the queen acted in the office by Mr Burchett. On the 29th November 1708, it was again put in commission, or rather, the Earl of Pembroke was constituted High Admiral, with a council to assist him; since which time, the office of Lord High Admiral has continued to be executed by seven Lords Commissioners of the Admiralty.

Prince George of Denmark, when Lord High Admiral, having surrendered, by a formal instrument, all the rights, profits, perquisites, and advantages whatsoever, appertaining to the office, for the benefit and use of the public, with the exception of the sum of L. 2500 a-year, to be disposed of in such manner, and for such particular uses, as her Majesty, under her sign manual, should direct; the salary of the Lord High-Admiral, which had hitherto been no more than 300 marks, was now fixed by warrant under privy-seal, at L. 7000 a-year; which sum, by 1st George II. was divided equally among seven commissioners, and continued to be so down to the present time, the part of the commissioner who stood first in the patent having, however, been made up, from other funds, to L. 3000 a-year, and, in the year 1806, further increased by Lord Howick, then first lord-commissioner, to L. 5000 a-year. Since the surrender above mentioned, all the *droits of Admiralty*, as they are called, with all the fees, emoluments, perquisites, &c. whatsoever, have been taken from the Admiral, and applied to public purposes.

These droits and perquisites are by no means inconsiderable. As enumerated in the patent, they consist of flotson, jetson, lagon, treasure, deodands, derelicts found within his jurisdiction; all goods picked up at sea; all fines, forfeitures, ransoms, recognizances, and pecuniary punishments; all sturgeons, whales, porpusses, dolphins, rigs, and grampusses, and all such large fishes; all ships and goods of the enemy coming into any creek, road, or port, by stress of weather, mistake, or ignorance of the war; all ships seized at sea, salvage, &c. together with his

shares of prizes; which shares were afterwards called *tenths*, in imitation, probably, of the French, who gave their admiral, for supporting the dignity of his office, *son droit de dixieme*. All prizes are now wholly given up by the crown to the captors; and such share of the *droits* as, from circumstances, may be thought proper. The Lord High-Admiral also claimed, and enjoyed as his due, the cast ships, and the subordinate officers of the navy, as their perquisites, all other decayed and unserviceable stores.

Though, by act of 2d William and Mary, the Lords Commissioners of the Admiralty are vested with all and siugular authorities, jurisdictions, and powers, which have been, and are vested, settled, and placed in the Lord High-Admiral of England for the time being, to all intents and purposes, as if the said Commissioners were Lord High Admiral of England, yet there is this remarkable difference in the two patents by which they are constituted, that the patent of the Lord High Admiral mentions very little of the military part of his office, but chiefly details his judicial duties as a magistrate; whilst, on the contrary, the patent to the Lords Commissioners of the Admiralty is very particular in directing them to govern the affairs of the navy, and is almost wholly silent as to their judicial powers.

These powers, as set forth in the patent to the Earl of Pembroke, in 1701, are, the power to act by deputy, to take cognizance of all causes, civil and maritime, within his jurisdiction; to arrest goods and persons; to preserve public streams, ports, rivers, fresh waters, and creeks whatsoever, within his jurisdiction, as well for the preservation of the ships, as of the fishes; to reform too straight nets, and unlawful engines, and punish offenders; to arrest ships, mariners, pilots, masters, gunners, bombadiers, and any other persons whatsoever, able and fit for the service of the ships, as often as occasion shall require and wheresoever they shall be met with; to appoint Vice-admirals, Judges, and other officers, *durante bene placeto*; to remove, suspend, or expel them, and put others in their places, as he shall see occasion; to take cognizance of civil and maritime laws, and of death, murder, and maim.

It was by no means necessary that the Lord High Admiral should be a professional man. Henry VIII. made his natural son, the Duke of Richmond, Lord High Admiral of England, when he was but six years old. When the High Admiral, however, went to sea in person, he had usually a commission under the great seal, appointing him admiral and captain-general of the fleet, sometimes with powers to confer knighthood, and generally to punish with life and limb. Such a commission was granted by Henry VIII. to Sir Edward Howard, who executed indenture with the king to furnish 3000 men, 18 captains, 1750 soldiers, 1232 mariners and gunners; the pay of himself to be 10s. a-day, of a captain 1s. 6d., of the rest 5s. as wages, and 5s. for victuals each man, for twenty eight days, together with certain dead shares.

It appears, from Mr Pepy's *Naval Collections*, that the Lord High Admiral did anciently wear, on solemn occasions, a gold whistle, set with precious stones, hanging at the end of a gold chain. The whistle, it would seem, has long since descended to the boatswain and his mates. (K.)



ADMIRALTY (HIGH COURT OF). This is a court of law, in which the authority of the Lord High Admiral is exercised, in his *judicial* capacity, and wherein all causes are determined appertaining to the sea, and all offences tried that are committed thereon. Very little has been left on record of the ancient prerogative of the Admirals of England. For some time after the first institution of the office, they judged all matters relating to merchants and mariners, which happened on the main sea, in a summary way, according to the laws of Oleron, promulgated by Richard I. These laws, which were little more than a transcript of the Rhodian laws, became the universally received customs of the western part of the world. "All the sea-faring nations," says Sir Lionel Jenkins, "soon after their promulgation, received and entertained these laws from the English, by way of deference to the sovereignty of our kings in the British ocean, and to the judgment of our countrymen in sea affairs."

In the patents granted to the early admirals, between the latter end of the reign of Henry III. and until the close of that of Edward III. no mention is made of marine perquisites, or of civil power, nor does it appear that the Admirals enjoyed either; but, after the death of the latter, new and extraordinary powers were granted to them, and it would appear that they usurped others. The preamble to the statute of 13th Richard II. sets forth, that "forasmuch as a great and common clamour and complaint hath been oftentimes made before this time, and yet is, for that the Admirals and their deputies hold their sessions within divers places of this realm, accroaching to them greater authority than belongeth to their office, in prejudice of our lord the King, and in destruction and impoverishing of the common people;" and it is therefore directed that the Admirals and their deputies, shall not meddle, from henceforth, of any thing done within the realm, but only of a thing done upon the sea: and two years afterwards, in consequence, as stated in the preamble of the statute, "of the great and grievous complaint of all the commons;" it was ordained that the Admiral's court should have no cognizance of any contracts, pleas, or quarrels, or of any thing done or arising within the bodies of counties, whether by land or by water, nor of wreck of the sea; but that the Admiral should have cognizance of the death of a man, and of maihern done in great ships, being and hovering in the main stream of great rivers, yet only beneath the bridges of the same rivers nigh the sea. He may also arrest ships in the great floats for the great voyages of the king, and of the realm; and have jurisdiction over the said floats, but during the said voyages only. But if the Admiral or his lieutenant exceed that jurisdiction, then, by 2d Henry IV., the statute of 13th Richard II. and common law may be holden against them; and if a man pursues wrongfully in the Admiralty Court, his adversary may recover double damages at common-law, and the pursuant, if attainted, shall incur the penalty of L. 10 to the King.

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The place, which, according to Spelman, is absolutely subject to the jurisdiction of the Admiral, is the sea; which, however, comprehends public rivers, fresh waters, creeks, and all places whatsoever, within the ebbing and flowing of the sea, at the highest water, the shores or banks adjoining, from all the first bridges to the seaward; and, in these, he observes, the Admiralty hath full jurisdiction in all causes, criminal and civil, except treasons and the right of wreck. Lord Coke observes, that "between the high-water mark and the low-water mark, the Admiral hath jurisdiction *super aquam*, when the sea is full, and as long as it flows, though the land be *infra corpus comitatus*, at the reflow, so as of one place there is *divisum imperium* at several times."

But, though the statute restraineth the Lord High Admiral, that he shall not hold plea of a thing rising in the body of a country, he is not restrained from making execution upon the land, but is empowered to take either body or goods upon the land; otherwise his jurisdiction would often prove a dead letter. He also can and does hold his court in the body of a county. So, likewise, the civil power may apprehend and try persons who may have been guilty of offences cognizable at common law, though committed in the fleet, in any port or harbour of Great Britain, or at sea, provided such persons have not already been tried for such offences, either by court martial, or in the Admiralty Court; and in all ports, harbours, creeks, &c. lying in any county, the High Admiral and the sheriff, or coroner, as the case may be, have concurrent jurisdiction.

The Lord High Admiral is assisted in his *judicial* functions by the following principal officers:

1. The Vice-Admiral.
2. The Judge.
3. The Registrar.
4. The Marshal.
5. Advocate-general.
6. Procurator-general.
7 Counsellor.
8. Solicitor.

1. *The Vice-Admiral.* This officer is the admiral's deputy, or lieutenant, mentioned in the statutes of 13th and 15th Richard II., and was the person most probably who presided in the court. At present the Vice-Admiral of England is a perfect sinecure, generally conferred on some naval officer of high rank and distinguished character in the service, having a salary attached to it in addition to his half pay of L. 469, 5s. 8d. *per annum.* The *Rear-Admiral of England* is the same, and the *salary*, in addition to his half pay, is L. 370, 4s. 3d. *per annum.* Each county of England has its Vice-Admiral, which is little more than an honorary distinction, though the patent gives to him all the powers vested in the Admiral himself. Similar powers were also granted to the judges of the Admiralty county courts; but this was found so inconvenient and prejudicial to those who had suits to commence or defend before them, that the Duke of York, when Lord High Admiral in 1663, caused instructions to be drawn up in order to ascertain to each his province; whereby the whole judicial power remained with the judge, and the upholding the rights of the Admiral, and levying and receiving his perquisites, &c. appertained to the Vice-admiral.

Each of the four provinces of Ireland has its Vice-Admiral: there is one Vice-Admiral for all Scotland, who has a salary of L. 1000 a-year on the ordinary estimate of the navy, and one for the Shetland and Orkney islands. The governor of most of our colonies has a commission of Vice-Admiral granted to him by the Lord High Admiral, or Lords Commissioners of the Admiralty; and generally a commission from the king, under the great seal, grounded on the 11th and 12th William III. and farther confirmed by 46th Geo. III. by which he is authorized to try all piracies, felonies, or robberies committed on the seas, where the parties are taken into custody in places remote from England; the court to consist of seven persons at the least, of which the governor, the lieutenant-governor, the vice-admiral, the flag-officer, or commander in chief of the squadron, the members of the council, the chief justice, judge of the vice admiralty court, captains of men of war, and secretary of the colony, are specially named in the commission; but any three of these, with four others selected from known merchants, factors, or planters, captains, lieutenants or warrant-officers of men of war, or captains, masters, or mates of merchant ships, constitute a legal court of piracy.

The Vice-Admiralty courts in the colonies are of two descriptions. The one has power to inquire into the causes of detention of enemies, or neutral vessels, to try and condemn the same for the benefit of the captors, as well as to take cognizance of all matters relating to the office of the Lord High Admiral. The other has power only to institute inquiries into misdemeanours committed in merchant vessels, and to determine petty suits, &c. and to guard the privileges of the Admiral. The former are usually known by the name of *Prize Courts*; the latter by that of *Instance Courts.*

The following are the colonies and foreign possessions in which *Prize Courts* have been established in the course of the last war. Gibraltar, Malta, Newfoundland, Halifax, Bermuda, Bahama Islands, Barbadoes, Antigua, Tortola, Jamaica, Cape of Good Hope, Ceylon, Bombay, Madras, and Calcutta. The following colonies had *Instance Courts* only; Dominica, Grenada, St Vincents, St Christophers, Trinidad, St Cervix, Martinique, Berbice, Demerara, and Essiquibo; in addition to which is a court established at Sierra Leone for the trial and condemnation of captured slaves only.

In none of the patents to the Lord High Admiral, Vice-Admiral, or Judge, is any mention made of prize jurisdiction. Lord Mansfield had occasion to search into the records of the Court of Admiralty in Doctor's Commons, to ascertain on what foundation this jurisdiction was exercised by the judge of the Admiralty, but he could not discover any prize-act books farther back than 1643: no sentences farther back than 1648. The Registrar could go no farther back than 1690. "The prior records," says his Lordship, "are in confusion, illegible, and without index." The prize jurisdiction may therefore be considered as of modern authority, and distinct altogether from the ancient powers given to the Admi-

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The Admiralty Court being in this respect a court in which foreigners of all nations may become suitors, an appeal may be had from its decisions to a committee of the Lords of His Majesty's Privy Council, who hear and determine according to the established laws of nations.

At the breaking out of a war, the Lord High Admiral also receives a special commission from the crown, under the great seal, to empower him to grant letters of marque and reprisals against the enemy, he having no such power by his patent. These letters are either general or special;—general, when granted to private men to fit out ships at their own charge to annoy the enemy;—special, when in the case of any of our merchants being robbed of their estates or property by foreigners, the king grants them letters of reprisal against that nation, though we may be in amity with it. Before the latter can be sued for, the complainant must have gone through the prosecution of his suit in the courts of the state whose subjects have wronged him; where if justice be denied, or vexatiously delayed, he must first make proof of his losses and charges in the Admiralty Court here; whereupon, if the King is satisfied he has pursued all lawful means to obtain redress, and his own interceding should produce no better effect, special letters of reprisal are granted; not, however, as must be evident, until a very strong case has been made out. This custom, which we may now consider as obsolete, seems to be a remnant of the law of ancient Greece, called *androlepsia*, by which, if a man was slain, the friends and relations of the deceased might seize on any three citizens of the place where the murderer took refuge, and make them slaves, unless he was delivered up. Both Oliver Cromwell and King Charles II. have granted letters of reprisal. In 1638, the Duc d'Epernon seized on the ship Amity of London, for the service of the French king against the Spaniards, promising full satisfaction; but none being made, the owners obtained letters of reprisal from the usurper, and afterwards, in 1665, from Charles II. In 1666, Captain Butler Barnes had letters of reprisal against the Danes. The Dutch having burnt six English merchant ships in the Elbe, within the territories of Hamburgh, which city, instead of giving any assistance or protection, hindered the English from defending themselves, letters of reprisal were granted to the sufferers against that city. Lastly, one Justiniani, a noble Genoese, being indebted in a great sum to Joseph Como, a merchant in London, which he had several years solicited for, but could get no satisfaction, Captain Scott, commander of his Majesty's ship the Dragon, stationed at that time in the Mediterranean, received orders to make reprisals upon the ships of that republic; upon which the debt was paid. Admiralty.

2. *The Judge.* The patents to the Judge of the Admiralty and Vice-Admiralty courts run pretty nearly in the same manner as those of the Lord High Admiral, and point out the several matters of which he can take cognizance. The parliament of 1640 established the office of Judge of the Admiralty court in three persons, with a salary of L. 500 a-year to each. At the Restoration, there were two judges of the High Court of Admiralty, which sometimes proved inconvenient; for when they differed in opinion no judgment could be had. These judges, before the Revolution, held their appointment only during pleasure. At that period, Sir Charles Hedges was constituted judge under the great seal of England, *quamdiu se bene gesserit*, with a salary of L. 400 a-year, and an additional L. 400 out of the proceeds of prizes and perquisites of the Admiralty; but in the year 1725 the latter sum was diminished from the ordinary estimate by the House of Commons. Sir William Scott, the present judge, in consequence of the extraordinary increase of the business in the Admiralty Court, has a salary of L. 2500 a-year on the ordinary estimate of the navy.

The judges of the Vice-Admiralty courts in certain of the colonies, limited by 41st George III., are allowed a salary not exceeding to each the sum of L. 2000 a-year, to be paid out of the consolidated fund of Great Britain; together with profits and emoluments, not exceeding to each the farther sum of L. 2000 *per annum* out of the fees to be taken by the said judges, of which a table is directed to be hung up in some conspicuous place in the court; and no judge is to take any fee beyond those specified, directly or indirectly, on pain of forfeiture of his office, and being proceeded against for extortion: and on his retirement from office, after six years' service, his Majesty may, by authority of the act above mentioned, grant unto such judge an annuity for the term of his life, not exceeding L. 1000 *per annum*. This liberal provision puts the judges of the colonial courts of Vice-Admiralty above all suspicion of their decisions being influenced by unworthy motives; a suspicion they were not entirely free from when their emoluments depended mainly on their fees.

During the late war, a session of oyer and terminer to try Admiralty causes was held at the Old Bailey twice a-year. The commission for this purpose is of the same nature with those that are granted to the judges when they go the circuits: that is to say, to determine and punish all crimes, offences, misdemeanours, and abuses; the *end* of both being the same, their *limits* different; the one relating to things done upon the land, the other to things done upon the water. The Lords Commissioners of the Admiralty, all the members of the Privy-Council, the Chancellor and all the judges, the Lords of the Treasury, the Secretary of the Admiralty, the Treasurer and Commissioners of the navy, some of the Aldermen of London, and several Doctors of the civil law, are the members of this commission, any four of whom make a court, the quorum being the Lords of the Admiralty, Judge of the Admiralty, the Twelve Judges, and the Doctors of the civil law.

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The session of oyer and terminer lasts generally from one to three days, and the court is entertained each day with a dinner at the expence of the Lord High Admiral, that is to say, of the public.

The proceedings of the court are continued *de die in diem*, or as the stile of the court is, from tide to tide.

3. *The Registrar of the Admiralty* has hitherto held his place by patent from the Lord High Admiral generally for life, though the admiral himself, and the Lords Commissioners of Admiralty hold their places only during pleasure; and what is still more remarkable, the office of Registrar has sometimes been granted, and is now vested in reversion. He had no salary; the amount of his emoluments depending on the number of captures, droits, &c. condemned by the court; which, during the late war, were so enormous, that in 1810, an act was passed for regulating the offices of Registrars of Admiralty and prize courts, by which it is enacted, "that no office of registrar of the high court of admiralty, or of the high court of appeals for prizes, or high court of delegates in Great Britain, shall, after the expiration of the interest now vested in possession or reversion therein, be granted for a longer term than during pleasure, nor be executed by deputy; that an account be kept in the said offices respectively of all the fees, dues, perquisites, emoluments, and profits received by and on account of the said Registrars, out of which all the expences of their offices are to be paid; that one-third of the surplus shall belong to the Registrar and to his assistant, (if an assistant should be necessary,) and the remaining two-thirds to the consolidated fund of Great Britain, to be paid quarterly into the Exchequer, the account of such surplus to be presented to the court at least fourteen days before each quarter day, and verified on oath."

4. *The Marshal.* This officer receives his appointment from the Lord High Admiral or Lords Commissioners of the Admiralty, and holds his situation by patent under the seal of the High Court of Admiralty, during pleasure. His duties are to arrest ships and persons, to imprison in the Marshalsea, to bear the mace before the judge, and to attend executions. His emoluments depend chiefly on the number of prizes brought into port for condemnation, and the number of ships embargoed, and may probably be reckoned in time of war, *communibus annis*, from L. 1500 to L. 2000 a year, out of which he has to pay about L. 400 a year to a deputy. In peace, the whole emoluments are probably not sufficient for the payment of the deputy's salary.

5. *The Advocate-General.* This officer is appointed by warrant of the Lords Commissioners of the Admiralty. His duties are, to appear for the Lord High Admiral in his Court of Admiralty, Court of Delegates, and other courts; to move and debate in all causes wherein the rights of the Admiral are concerned, for which he had anciently a salary of twenty marks a year, and an additional allowance granted to him in 1695, of L. 200 a year. At present he has L. 213, 6s. 8d. a year, voted on the ordinary estimate of the navy. Formerly, the Admiral's Advocate was always retained as leading counsel, but since the droits were transferred to the crown, he has gradually been supplanted by the King's Advocate, who is generally retained in all cases, the Admiralty Advocate acting only as junior counsel; and while the former makes sometimes from L. 15,000 to L. 20,000 a year, the latter rarely receives from his professional duties more than from L. 1500 to L. 2000 a year. This difference however, may probably be owing in a great degree to the personal character of the men who hold the two situations.

6. *The Procurator.* The Admiralty's Proctor stands precisely in the same situation to the King's Proctor, that his advocate does to that of the King, though there is not quite so great a difference in their emoluments. They act as the attornies or solicitors in all causes concerning the King's and the Lord High Admiral's affairs in the High Court of Admiralty and other courts. All prize causes are conducted by the King's Proctor, which the captors are disposed to consider as a grievance, but which the gentlemen of Doctors Commons on the contrary maintain to be for their convenience and advantage. It is supposed, that in some years of the war, the King's Proctor did not receive less than L. 20,000 a year.

7. *The Counsel of the Admiralty* is the law officer who is chiefly consulted on matters connected with the military duties of the Lord High Admiral; his salary is L. 100 a year besides his fees, which, in time of war, may be reckoned to amount from L. 1200 to L. 1800 a year.

8. *The Solicitor to the Admiralty,* is also an officer more immediately connected with the military functions of the Admiralty. He is stated sometimes assistant to the counsel; his salary is L. 400 in lieu of all fees; and his disbursements for the naval departments in time of war, amount to L. 14,000 or L. 15,000 a year.

*The Judge Advocate* of the fleet is a sinecure appointment, with a salary of L. 182, 10s. a year, on the ordinary estimate of the navy; but the *Deputy Judge Advocate* resides at Portsmouth, and assists at all courts martial held at that port, for which he is allowed an annual salary of L. 146. See NAVY, in this Supplement. (K.)

ÆPINUS, (FRANCIS ULRICH THEODORE) eminent in the mathematics, and in natural philosophy, was born at Rostock in Lower Saxony, in 1724, and died at Dropt in Livonia in 1802. We regret that our means of information do not enable us to communicate any particulars in regard to his personal history; but we shall give some account of his contributions to science, and these, after all, form the most interesting memorials of a philosopher's life.

The work by which he is best known, is entitled, *Tentamen Theoriæ Electricitatis et Magnetismi,* published at Petersburgh in 1759. It appeared under the sanction of the Imperial Academy, to which the theory had been in part communicated; and it is said on the title page to be *Instar Supplementi Comment. Acad. Petropolitanæ.* The work indeed merited this distinction, as being the first systematic and successful attempt to apply mathematical reasoning to the subjects of electricity and magnetism. Already the theory of Franklin, with regard to the former, was very generally received, and was supposed to afford a satisfactory explanation of the phenomena. But though it seemed sufficient for this purpose in

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the common and somewhat loose manner in which the matter had hitherto been treated, it was not certain that the same would hold when the conclusions were accurately and mathematically deduced. To apply this test was what Æpinus undertook, and what he has executed in a manner very satisfactory and complete. He has treated very fully, and perhaps has nearly exhausted what may be called the *statics* of electricity and magnetism, or the equilibrium of their forces. A great field yet remains, where the motion of the electric fluid is to be considered, and its distribution over the surfaces of bodies of a given figure; where greater difficulties are to be encountered, and where the latest improvements of the integral calculus in the hands of La Place and Poisson have begun to be applied. The investigations of Æpinus in their own department led to very satisfactory results, and the exact agreement between them and the phenomena actually exhibited was extensively observed. Notwithstanding this agreement, we cannot consider the theory of positive and negative electricity as being yet sufficiently established. Though the assumption on which it is founded appear very simple at first, it is found more complex on a nearer inspection. The assumption is, that a fluid resides in the surfaces of all the bodies termed electrics, which is highly elastic, and strongly attracted, at the same time, by the particles of the body, and that while this fluid remains equally diffused over the surface of the body, no phenomenon whatever gives any information of its existence. By certain mechanical operations, however, the equilibrium of this fluid may be destroyed; the fluid may be accumulated at one end, or on one side of a body, and entirely withdrawn from the opposite. It is when an electric is brought into this state that it exhibits the phenomena of electricity, between which, and the calculus instituted on the suppositions just laid down, Æpinus has everywhere remarked the most exact agreement. One great difficulty, however, still remains. The negative ends of two electrified bodies repel one another, just as much as the ends which are reckoned positive. But such an effect cannot result from the mere absence of a substance; when the electric fluid is withdrawn, if repulsion still continue, it must arise from the mutual action of the particles of the body itself. Thus it would appear, that, in the absence of the electric fluid, the tendency of the particles of matter is to repel one another. This is an essential part of the theory; and it is not accurate to say, that the doctrine of Franklin or Æpinus supposes no more than the existence of an elastic fluid diffused over the surfaces, and strongly attracted by the particles of bodies. It supposes, besides, that those particles, in the absence of this fluid, mutually repel one another. This not only takes away from the simplicity of the hypothesis, but it is obviously a very unnatural, not to say a contradictory supposition; because, when the electric matter is removed, how comes it to pass that the particles of the body, notwithstanding their mutual repulsion, still cohere together as firmly as before? This difficulty is acknowledged by Æpinus himself; but it would seem that the theory had taken a strong hold of his mind before he was aware of this consequence from it, so that he became by degrees reconciled to a supposition which appeared to him a first not a little incongruous. This must not surprise us: It is not always that, even among philosophers, we meet with the candour, or perhaps we should say the courage, with which Newton suspended his belief in his own great discovery, the principle of universal gravity, as long as the erroneous opinion then existing, about the magnitude of the earth, made the moon's motion in her orbit appear inconsistent with the descent of falling bodies.

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Another remark, made by Æpinus himself, involves in it a difficulty which should have induced him to view his theory with considerable diffidence. Though he considers the difference of the two electricities to be the same as between excess and defect, or to consist in this, that the fluid which is deficient in the one part is in excess in the other, he admits that no phenomenon points out on which side the excess, or on which the defect lies. This is a strong indication that the difference is not of the kind supposed. We are not left at a loss to tell whether cold is the absence of a substance which we call heat, or heat the absence of a substance which we call cold. If there were just as much reason for asserting the one of these propositions as the other, one would certainly be inclined to reject both. The same should be done with respect to electricity and magnetism.

The investigations of Æpinus, however, are by no means rendered useless, even if the theory of positive and negative electricity, or of positive and negative magnetism be exchanged for that of two elastic fluids, each attracting the other, and both attracted by the particles of bodies. Most of his investigations may be easily accommodated to this supposition, and, therefore, they are, fortunately for themselves and for their author, of a more permanent nature than the principles from which they were deduced.

It is to be added to this, that Æpinus was the first who saw the affinity between electricity and magnetism, in its full extent, and perceived the light that these two mutually cast on one another. He instituted a regular series of experiments on the nature of the *Tourmaline*, on which he wrote a small treatise, published in 1762. He is to be regarded also as the inventor of the Condenser of Electricity, and of the Electrophorus, of which he gave the complete theory.

A very excellent view of the theory of Æpinus was published at Paris by M. Haüy, in 1787, in 8vo. The same author has, however, adopted the theory of the two fluids in his own treatise, *Leçons de Physique*. There is a remarkable coincidence between Æpinus's work on electricity and magnetism, and that of Mr Cavendish, given in the *Philosophical Transactions* for 1771, p. 584. The principles from which they set out, and the conclusions at which they arrive, are in a great measure the same. It appears, however, quite certain, that Mr Cavendish knew nothing of the work of the Russian philosopher till his own was completed. His mode of proceeding is more geometrical, and in some parts he has gone farther.

The researches of Æpinus were not confined to the subjects now mentioned, but extended to most of the branches of natural philosophy. Beside the treatise

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on the Tourmaline, he published, in 1762, a work, in 4to, *On the distribution of heat at the surface of the earth;* a work which, though translated into French, has hardly, we believe, made its way into this country, and of which we are therefore unable to speak from our own knowledge. He is also the author of many valuable memoirs on different subjects in pure mathematics, in astronomy, mechanics, optics, meteorology, contained in the 7th, 8th, 9th, 10th, and 12th volumes of the *Novi Commentarii Petropolitanæ*, and in the volumes of the *Berlin Memoirs*, for 1755, 1756. In a memoir contained in the last of these is the first account of his experiments on the Tourmaline, which were conducted with great accuracy and judgment, and do honour to the author as a man of a sound and philosophical understanding, well instructed in the true principles of inductive investigation. Indeed, notwithstanding the objections we have made to his theories of electricity and magnetism, we must acknowledge that this is the general impression produced by the perusal of his works. He appears to have been well acquainted with practical astronomy, and sometimes to have had the charge of the Imperial Observatory. He made improvements on the Micrometer and the Reticulum, and wrote a memoir on the effects of parallax in the transit of a planet over the sun; a difficult subject, and one rendered at that time (1764) peculiarly interesting, on account of the transit of Venus which was just past, and that which was soon expected. (*Novi Com. Pet.* Tom. X. p. 433.) In the same volume he has a memoir on the subject of *accidental colours*, which at that time had hardly been treated of by any author but Buffon; and another on the affinity between electricity and magnetism. In the 12th volume he notices, we believe for the first time, the electric property of the Brasilian emerald. He was not aware that this emerald is in reality the green Tourmaline (*Brogniart*, Tom. I. p. 418.); a variety of that mineral on which he had already exercised his ingenuity with so much success.

It is rare, in an advanced state of science, to have the satisfaction of making a new discovery with regard to a subject quite elementary, and one that has been long a subject of attention. This, however, happened to Æpinus with respect to the *Lever*, and to the simplest kind of lever—that which has equal arms; of which he has demonstrated a new property in the 8th volume of the *Commentaries* above referred to. It is this:—If a lever, with equal arms, be acted on at its opposite ends by forces, in a given ratio to one another, and having their directions parallel to straight lines given in position, and if these forces be resolved each into two, one at right angles to the lever, and the other in the direction of it: in the case of equilibrium, the sum of the two forces, having the same direction with the lever, will be the *greatest possible.* This theorem, remarkable for its simplicity, and for illustrating the connection between the equilibrium of bodies, and certain problems concerning the maxima or minima of variable quantities, occurred when he was pursuing some of his inquiries concerning magnetism. He seems not to have been very fortunate, however, in his investigation, which is more complex than is necessary, as the proposition admits of a geometrical demonstration, remarkable for its simplicity. (L.)

AEROLITE, a term recently, but perhaps improperly, applied to those singular substances commonly called METEORIC STONES. The reader will find an interesting article upon this subject under the word METEOROLITE in the body of the work; and we shall give such additions as may be necessary, under the same head, in this Supplement.

# AERONAUTICS.

UNDER the article *Aerostation* in the Encyclopædia, the memorable invention of Balloons, the methods employed for constructing those aërial vehicles, with the remarkable circumstances attending their earlier ascents, are related at some length. But since that article was drawn up, several voyages have been performed through the atmosphere with more brilliant success, and often directed to the purposes of philosophical research. The various attempts at mounting into the air, and the progress of opinion among men respecting such a wonderful art, deserved likewise more notice, as interesting monuments at once of human ingenuity and of human weakness. The term *Aerostation*, first used, and signifying merely *the weighing of air*, might seem to refer simply to the buoyant property of balloons, and to preclude all discussion concerning the circumstances which determine their floating in any given stratum, or which regulate the force and celerity of their ascension, or of their subsequent descent. We prefer, as more correct and appropriate, the word *Aeronautics*, now generally adopted to express *aërial navigation.* Following out this more extended signification, we design at present to take a retrospect of the whole subject; to mark the progression of science; to detail more fully the steps by which Montgolfier arrived at this capital discovery; to explain the calculation of the ascent and stability of balloons; and, passing rapidly over the different aërial navigations related before, to select some of their more varied and striking features; and to conclude with the narrative of two magnificent ascents in the atmosphere lately made in France, and undertaken solely from philosophical views.

Gradual Discovery of Navigation.

In every stage of society, men have eagerly sought, by the combination of superior skill and ingenuity, to attain those distinct advantages which nature has conferred on the different tribes of animals, by endowing them with a peculiar structure and a peculiar force of organs. The rudest savage learns, from his very infancy, to imitate the swimming of a fish, and plays

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on the surface of the water with an agility and a perseverance, which seem to decline with the advancement of civilization. But an art so confined in its exercise, and requiring such a degree of bodily exertion, could not be considered of much avail. It was soon perceived, that the fatigue of impulsion through the water could be greatly diminished, by the support and floating of some light substance. The trunk of a tree would bear its rude proprietor along the stream; or, hollowed out into a canoe, and furnished with paddles, it might enable him even to traverse a river. From this simple fabric, the step was not great to the construction of a boat or barge, impelled by the force of oars. But it was a mighty stride, to fix masts and apply sails to the vessel, and thus substitute the power of wind for that of human labour. The adventurous sailor, instead of plying on the narrow seas, or creeping timidly along the shore, could now launch with confidence into the wide ocean. Navigation, in its most cultivated form, may be fairly regarded as the consummation of art, and the sublimest triumph of human genius, industry, courage, and perseverance.

Vain Attempts to fly through the Air.

Having achieved by his skill the conquest of the waters that encompass the habitable globe, it was natural for man to desire likewise the mastery of the air in which we breathe. In all ages, accordingly, has ingenuity been tortured in vain efforts at flying. The story of Icarus testifies how fatal such daring attempts had generally proved to their projectors. Trials made with automatons, though less liable to risk and danger, were yet equally fallacious. Archytas, a most eminent Greek geometer and astronomer, who perished by shipwreck on the coast of Calabria, was believed by his admiring contemporaries to have constructed an artificial dove, which, by the action of a system of internal springs, wafted itself through the air. If such a piece of mechanism was ever made, we may be sure that its flight was really produced, as in the scenes of the opera, by means of invisible strings or wires.

Flying ascribed to Demons,

So thoroughly were the ancients convinced of the impossibility of men being able to fly, that they ascribed the absolute rule of the sky to Divinities of the first order. The supreme Jupiter alone reposed on his empyreal throne, far above the heights of Olympus; and to him was it given, from the region of the clouds, to point the winged lightning, and to hurl the flaming thunderbolt. On special missions, he dispatched Mercury, as his messenger, through the wide range of atmosphere The Oriental Nations, from whom we have borrowed the greater part of our vulgar mythology, likewise committed such journies to certain genii, or ministering spirits. But the glowing visions of the East received a darker tinge from the character and climate of our Gothic ancestors. The Arch-Fiend himself was, at no very distant period, firmly believed to have the especial control of the air, and to career in the whirlwind, and impel the howling tempest. Those wretched creatures, whom the unfeeling credulity of our ancestors, particularly during the prevalence of religious fanaticism, stigmatized and murdered under the denomination of witches, were supposed to work all their enchantments, to change their shapes at will, and to transport themselves through the air with the swiftness of thought, by a power immediately derived from their infernal master. At a period somewhat earlier, every person in possession of superior talents and acquirements, was believed to deal in magic, and to perform his feats of skill, chiefly through the secret aid granted him by the Prince of Darkness. In spite of the incurable perverseness of his conduct, it must be confessed that the Devil has always had the credit of retaining some little inclination to assist the efforts of genius.

and to Magicians.

During the darkness of the middle ages, every one at all distinguished by his knowledge in physics was generally reputed to have attained the power of flying in the air. Our famous countryman, Friar Bacon, among other dreams engendered in his fervid brain, has not scrupled to claim the invention of that envied and transcendant art. To these pretensions the credulity and indulgent admiration of some authors have lent more credit than they really deserved. Any person who will take the trouble to examine the passages of Bacon's obscure, though ponderous works, must soon be convinced, that the propositions advanced by him are very seldom founded on reality, but ought rather to be considered as the sportive illusions of a lively and teeming fancy. Albertus Magnus, who lived about the same period, and was esteemed in Germany as a perfect prodigy, pretended also to the art of flying. More than a century afterwards, John Müller of Köningsberg, and thence styled *Regiomontanus*, one of the chief restorers of genuine mathematical learning in Europe, was reported, by some writers of note, to have, like Archytas, fashioned an artificial dove, which displayed its wings, and flew before the Emperor Charles V. at his public entrance into Nüremberg. But, unfortunately for the veracity of the story, Regiomontanus died in early life, full sixty years before that visit took place.

Dark features of that Art.

While the belief in necromancy prevailed, such tales assumed colours of the most lurid hue. Fiery dragons, created by infernal machination, were imagined to rush impetuous through the sky, vomiting flames, and widely scattering the seeds of pestilence. Grave writers, in those benighted ages, even ventured to describe the method of imitating the composition of such terrific monsters. A mass of large hollow reeds were to be disposed and bound together, then sheathed completely in skin, and smeared over with pitch and other inflammable matters: this light and bulky engine, partially set on fire, and launched in the thickest darkness into the air, might be sufficient, when borne along by the force of the wind, to strike the ignorant populace with affright and horror. But such spectacles would come to lose their terrors by repeated failure, and the insensible progress of knowledge. So late as the year 1750, a small Catholic town in Swabia was almost entirely burnt to ashes by an unsuccessful experiment of that sort, instigated, and probably directed, no doubt for the edification of their flock, by the lowest order of priests. It was attempted to represent the effigy of Martin Luther, whom the monks firmly believe to be the very imp of Satan, under the form of a winged serpent, furnished with all the requisite appendages of a forked tail

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and hideous claws. Unluckily for the skill of the machinist, this phantom directly fell against the chimney of a house, to which it set fire, and the flames spreading furiously in every direction, the people had soon cause to lament bitterly their intemperate zeal.

Later Attempts at flying.

The scheme of flying in the air, which men of the first genius had once entertained, appears to have gradually descended to a lower class of projectors. Those who afterwards occupied themselves with such hopeless attempts, had commonly a smattering of mechanics, with some little share of ingenuity, but wrought up by excessive conceit.

In the beginning of the sixteenth century, an Italian adventurer visited Scotland, during the reign of James IV., and being a man of some address, and at the same time a pretender to alchemy, he contrived to insinuate himself into the favour of that gay and needy prince, by holding out hopes of augmenting his scanty treasury by the acquisition of the philosopher's stone. He was collated by royal favour to the abbacy of Tungland in Galloway; but not having succeeded in creating artificial riches, he resolved, in the height of his enthusiasm, at once to gratify and astonish the courtiers, by the display of a feat still more extraordinary. Having constructed a set of ample wings, composed of various plumage, he undertook, from the walls of Stirling Castle, to fly through the air to France. This experiment he had actually the folly or hardihood to try, but he soon came to the ground, and broke his thigh-bone by the violence of the fall. For his unlucky failure, however, the Abbot had the dexterity to draw a very plausible excuse from the wretched sophistry, termed science in that age. "My wings," said the artful Italian, "were composed of various feathers; among them were the feathers of dunghill fowls, and they, by a certain sympathy, were attracted to the dunghill; whereas, had my wings been composed of the feathers of eagles alone, the same sympathy would have attracted them to the region of the air."—This anecdote has furnished to Dunbar, the Scottish poet, the subject of one of his rude Satires.

A century afterwards, Fleyder, rector of the grammar-school at Tübingen, entertained, in 1617, the worshipful magistrates of that city, with a lecture on the art of flying, which he published at the lapse of eleven years, yet prudently contented himself with barely explaining his theory. A poor monk, however, ambitious to reduce this theory into practice, having provided himself with spacious wings, took his flight from the top of a high tower; but, encountering a cross wind, his machinery misgave, and falling precipitously to the ground, he broke both his legs, and perished miserably. An accident of a similar kind is related to have happened not long since near Vienna.

Impossibility of flying demonstrated by Borelli.

The impossibility of rising, or even remaining suspended in the air, by the action of any machinery impelled by human force, was first demonstrated by Borelli, a most eminent Italian mathematician and philosopher, who lived in the fertile age of discovery, and was thoroughly acquainted with the true principles of mechanics and pneumatics. In his celebrated and excellent work *De Motu Animalium*, published in 1670, he showed, by accurate calculation, the prodigious force which the pectoral muscles of birds must exert and maintain. The same principles, applied to the structure of the human frame, proved how very disproportionate was the strength of the corresponding muscles in man. It is not, therefore, the mere difficulty of contriving and combining machinery which should perform the peculiar motions of wings, that has rendered all attempts of the kind futile, but the utter want of adequate force in the human body, to give such impulsion to those extended vanes as would be necessary for supporting so great a weight in the thin medium of the atmosphere.

Having found, by experience, the impossibility, from any application of inherent strength, of ascending into the atmosphere, it was natural for men of ardent minds, who still pursued that dazzling project, to look for some extraneous aid among the varied powers of the elements. The notions entertained by the ancients respecting the composition of the world, might have suggested important hints for realizing the scheme of aërial navigation. The four elements—earth, water, air, and fire, or æther, arranged according to their several qualities and tendencies, were supposed to constitute this universal frame. Earth, being heavy and inert, occupies the centre of the system, and above it flowed the waters; air, from its lightness, rose upwards, and invested the globe with an atmosphere; while the diffuse ethereal substance soared, by its extreme buoyancy, to the celestial regions, and filled with splendour their pure expanse. Every portion of these distinct elements, if transported from its place, was conceived as having a natural and constant appetency to return to its original situation. Earth and water sink downwards by their gravity, while air and fire, endued with an opposite principle, as invariably rise to the higher spaces. A portion of fire, joined to water or to air, communicates, in a corresponding degree, its levity or disposition to ascend. Thus, warm air always rises; water, subdued by excessive heat, flies upwards in the form of vapour; and the volatile parts of inflamed bodies are borne to the sky in smoke.

Cosmological Notions of the Ancients.

Idea of sailing through the Air first given by Albert of Saxony,

The first person that seems to have formed a just idea of the principle on which a balloon could be constructed, was Albert of Saxony, a monk of the respectable order of St Augustin, who lived in the fourteenth century, and wrote a learned commentary on the physical works of Aristotle. Since fire is more attenuated than air, and floats above the region of our atmosphere, this ingenious person conceived that a portion of such ethereal substance, inclosed in a light hollow globe, would raise it to a certain height, and keep it suspended in the sky. But the same philosopher rightly subjoined, that a greater mixture of air introduced into the balloon, by rendering this heavier than before, would cause it to descend proportionally, in the same way precisely, as water admitted through the seams of a ship, makes the vessel to sink in the ocean. It is evident that nothing was wanted for completing Montgolfier's discovery, but to carry those fine views into execution.

The ideas of Albert of Saxony were long after-

Aëronautics. and adopted by Mendoza,

wards zealously embraced by Francis Mendoza, a Portuguese Jesuit, who died at Lyons in the course of a tour through France, in 1626, at the age of forty-six. He maintained that the combustible nature of fire was no real obstacle to its application in balloons, since its extreme levity, and the exclusion of the air, would hinder it from supporting inflammation.

and Caspar Schott.

Caspar Schott, a Jesuit likewise, pursued more soberly the same speculation in Germany. He stated, that no air of these lower regions is ever light enough to produce an ascent, and that the lucid ethereal matter which swims above our atmosphere, is alone fitted for aërial navigation. Were any super-human power, therefore, to bring down a store of that buoyant substance, to be inclosed in a hollow ball of wood, or thin lead, the vessel, being furnished with a rudder and sails, might then, he conceived, boldly navigate the sky.

Blended with Alchemical Notions.

Similar notions have been renewed at different times. They were likewise often blended with the alchemical tenets, so generally received in the course of the fifteenth, sixteenth, and part of the seventeenth centuries. Conceiving with the ancients that the dew which falls during the night, is of celestial origin, and shed by the stars; speculative men still imagined this pure humidity to be drawn up again to the heavens by the sun's rays, in the heat of the day. Many persons, imbued with the wretched learning of that age, had the simplicity to believe that an egg-shell filled with the morning dew, and placed at the foot of a ladder, leaning against the roof of a house, would, as the day advanced, spontaneously rise along the bars, and mount to the chimney-tops.

Whimsical Projects of Father Laurus.

This whimsical fancy is confidently related as an observed fact, by Father Lauretus Laurus. "Take," says he, very gravely, "a goose egg, and having filled, it with dew gathered fresh in the morning, expose it to the sun during the hottest part of the day, and it will ascend, and rest suspended for a few moments." To perform the experiment on a greater scale, however, he proposed to employ the largest swan's egg, or a bag artificially prepared from the thinnest and lightest skin, into which, instead of dew, he would introduce the three alchemical elements, nitre, sulphur, and mercury; and he imagined that these active bodies, expanded and sublimed by the mere heat of the sun, must spring powerfully upwards. In this way, he thought the dove of Archytas might be constructed. But the visionary priest had yet another scheme to advance, for effecting the ascent of the automaton: He proposed to cram the cavity of the dove with highly condensed air, and was so grossly ignorant of the principles of motion, as to suppose that this imprisoned fluid would impel the machine, in the same manner as wind does a sail. Should such a force be found not sufficiently efficacious, he finally recommended the application of fire; not, however, on account of its buoyant property, but because of the propulsive power which it exerts. To prevent the fire from consuming the wooden machine, he recommends lining the inside with cloth of asbestos or other incombustible materials, and to feed and support steadily this fire, he suggested a compound of butter, salts, and orpiment, lodged in metallic tubes, which he imagined would, at the same time, heighten the whole effect, by emitting a variety of musical tones like an organ.

Proposals of Cardan and Fabry.

Influenced by the same views, other authors, and particularly the famous Cardan, have proposed, for aërial ascents, to apply fire acting as in a rocket. Still later, but in the same country, Honoratus Fabry, penitentiary of the Pope, and teacher in the Gymnasium at Rome, who died about the end of the seventeenth century, described a huge apparatus, consisting of very long tin pipes, in which air was compressed by the vehement action of fire below. In a boat suspended from the machine, a man was to sit and direct the whole, by the opening or shutting of valves.

Philosophical Romance of Cyrano de Bergerac.

The projects and vagaries of learned men about the misty period of the restoration of science, were finely ridiculed by Cyrano de Bergerac, a very witty and eloquent French writer, in a philosophical romance entitled, *The Comical History of the States and Kingdoms in the Sun and Moon.* This eccentric genius, born at Perigord in 1620, was noted for his impetuous temper and boiling courage. He spent his youth in dissipation and feats of arms; but afterwards, in riper life, he quitted the military profession, and betook himself to the study of poetry and philosophy, which he prosecuted, with great ardour and success, till he died, at the early age of thirty-five. In his romance, from which perhaps Swift borrowed the idea of Gulliver's voyage to Laputa, Bergerac introduced a good deal of the Cartesian philosophy, then just coming into vogue, but lashed severely the pedantry and ignorance of various pretenders to science. To equip himself for performing the journey to the moon, the French traveller fastens round his body a multitude of very thin flasks, filled with the morning's dew. The heat of the sun, by its attractive power, exerted on the dew, raised him up to the middle region of the atmosphere, where some of his flasks happening unluckily to break, the adventurer sunk again to the ground, and alighted in Canada. There he constructed a new machine, acting by a train of wheels, with which he mounted to some height, but falling down, he had the misfortune to break his leg. He crept aside, in search of ox-marrow to compose a salve, with which he instantly healed his bruises; and returning again, he found his engine in the possession of some soldiers, who had fixed to it a number of sky-rockets. Replacing himself now in the car, he applied fire to the rockets, and darted upwards with inconceivable swiftness; the earth retired gradually from view, while the orb of the moon appeared proportionally to expand, till, approaching the sphere of her activity, he was borne softly along, and descended, on the lunar surface, into a most delicious and luxuriant grove. Here, of course, he met with angelic personages, endowed with every perfection of body and mind, and far exalted above the mean vices, and the rancorous passions, which poison and inflame the inhabitants of this blood-stained globe. In the conversations which Bergerac held with those supernal beings, he was informed that a native of our planet, utterly disgusted at the crimes which pollute its "sin-worn mould," had once on a time provided himself with a pair of very large and thin metallic vessels, which he filled with smoke, and sealed in the

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light; and having attached himself below them, the buoyant power of the confined smoke carried him to the highest region of our atmosphere, where the attraction of the moon at length prevailing, drew him to her surface, while the great extent of the machinery, by opposing resistance, served to break the force of his fall. The moment, however, those slender capacious vessels were liberated from his weight, they rose again by the action of the smoke, till they reached a medium of the same density, and finally took their station in the bright fields of æther, where they form the constellation now called the *Balance*.

In farther discourse with his sublime instructor, our romantic voyager was shown, how to obtain the power of ascension from the loadstone. He was directed to take two magnets, each about a foot square, to roast them in the fire, to separate their impurities by solution, and thus concentrate their attractive virtue in a mere calx, which could be formed into a ball. Aided by such counsels, he now resolved to visit the sun. With much labour and perseverance, he constructed a chest of very thin steel, six feet high and three feet wide; an icosahedron of crystal, the highest of all the regular solids, being fitted into the top, and the bottom having a small valve which opened outwards. Into this chest he shut himself, while the sun's rays, concentrated and multiplied by reflexion from the numerous facets of the crystal, heated the air intensely, and drove a great part of it out below; and he ascended rapidly towards the glorious luminary, breathing extaticly in divine light, which gleamed with the richest tints of enamelled gold and purple.—But it would be foreign to our purpose to follow the rest of the narrative, which, though disguised and mingled with fantastic visions, evidently contains the true principles of aëronautics.

Lana's Scheme for Navigating the Air.

The most noted and elaborate scheme for navigating the atmosphere, was proposed by the Jesuit Francis Lana, in a book written in the Italian language, and printed at Brescia in 1670, with the aspiring title of *Prodromo dell' arte Maestra*. His project was, to procure four copper balls of very large dimensions, yet so extremely thin, that, after the air had been extracted, they should become, in a considerable degree, specifically lighter than the surrounding medium. He entered into some calculations, to prove that the buoyant power thus obtained would be fully adequate to produce the desired effect. Yet he seems to have had only a slender knowledge of geometry, and but little acquaintance with the progress of physical science. For instance, he founds his computations entirely on the pneumatical discoveries of Galileo and Toricelli, without making any reference to those important facts which the invention of the air-pump by Otto Guerické had successively detected, in the course of near thirty years. He assumes that air is 640 times lighter than water; that a cubic foot of water weighs 80 pounds, and consequently, that the weight of the same bulk of air is an ounce and a half. If we rectify the estimate of Lana, and reduce it to English measures, each of his copper balls had about 25 feet in diameter, with the thickness of only the 225th part of an inch, the metal weighing 365 pounds *avoirdupois*, while the weight of the air which it contained must amount to 670 pounds, leaving, after a vacuum had been formed, an excess of 305 pounds, for the power of ascension. Those four balls would, therefore, rise together into the atmosphere with a combined force of 1220 pounds, which was thought sufficient by the projector to transport a boat completely furnished with masts, sails, oars, and rudders, and carrying several passengers. To extract the air from their cavities, the method proposed was, to procure a Toricellian vacuum, by connecting each globe, fitted with a stop-cock, to a tube of at least thirty-five feet long; the whole being filled with pure water, and raised gently into a vertical position, the mass of liquid, exceeding the pressure of the atmosphere, would flow out, and subside to some point below the cock, which could then be shut.

His Calculations.

His Attempts to answer Objections.

Lana enumerates the different objections which might be urged against his scheme, and endeavours to answer them. He thinks that the spherical and perfectly arched form of the shell of copper would, notwithstanding its extreme thinness, enable it, after the exhaustion was effected, to sustain the enormous pressure of the external air, which, acting equally on every point of the surface, would rather tend to consolidate, than to crush or tear, the metal. As the atmosphere becomes always lighter in the upper regions, the machinery could only rise to a certain limit; and if this were found too high for easy breathing, the ascent could be regulated, by opening occasionally the cocks to admit some air into the cavity of the balls, and thus increase their specific gravity. There seemed to him no very great difficulty in directing and impelling the aërial bark, by means of rudders, oars, and sails; but the objection was more serious on account of the hazards of tremendous shipwreck, from the violence of winds and tempests. Yet what most alarmed the insinuating Jesuit, and which he earnestly prays God to avert, was the danger that would result, from the successful practice of the art of aëronautics, to the existence of civil government, and of all human institutions. No walls or fortifications could then protect cities, which might be completely subdued or destroyed, without having the power to make any sort of resistance, by a mere handful of daring assailants, who should rain down fire and conflagration from the region of the clouds.

So sanguine was Lana, as to conceive, that the very moderate sum of an hundred ducats would be sufficient to defray the expence of all this huge and delicate apparatus. But his poverty, fortunately, no doubt, for his credit as a man of learning, prevented him from proceeding farther than mere speculation; and none of the foreign princes, who, about that period, often squandered, like gamesters, much of their wealth, in the dark and chimerical search after the philosopher's stone, seemed any way disposed to engage in the magnificent scheme of aërial navigation.

The project of Lana appears to have, in some degree, excited the attention of the learned, though it was, at the same time, very generally condemned. Hook, Borelli, Leibnitz, and Sturmius, examined it, and severely exposed its defects. Indeed, any person at all acquainted with actual experiment, must see that it was absolutely impracticable. Passing over other

circumstances, the attenuated shell of copper, from its size and excessive thinness, could not have strength enough to support even its own weight, far less the slightest pressure of the atmosphere. The plate, however, that Lana has given, of his whole combined apparatus, appears very striking; and after Montgolfier's discovery, it could not fail to attract a greater share of notice than it was otherwise entitled to claim.

Project of Galien.

So late as the year 1755, and not very long before the final invention of balloons, a very fanciful scheme, yet on the grandest scale, for navigating the atmosphere, was published, with most circumstantial detail, in a small pamphlet, by Joseph Galien, a Dominican friar, and professor of philosophy and theology in the papal university of Avignon. This visionary proposed to collect the fine diffuse air of the higher regions, where hail is formed, above the summit of the loftiest mountains, and to inclose it in a bag of a cubical shape, and of the most enormous dimensions, extending more than a mile every way, and composed of the thickest and strongest sail-cloth. With such a vast machine, far outrivalling in boldness and magnitude the ark of Noah, it would be possible, he thought, to transport a whole army, and all their ammunitions of war. But we need not stop one moment to consider a project so perfectly chimerical, which involves, besides, the erroneous supposition that the air of the upper regions is, independently of its diminished compression, essentially thinner and more elastic than the air below.

It cannot fail to strike the reader, that the persons who have occupied themselves the most with attempts at aërial navigation, were all of them Catholic priests; —whether this pursuit is to be explained, from their habits of seclusion and their ignorance of the affairs of real life, or from their familiar acquaintance with the relations of miracles and other legendary tales, which might lead them to see nothing very extraordinary in the art of flying through the air. The various schemes of that kind, produced at different times, contain a few just principles, generally mixed up, however, with a large portion of absurdity. But very wide is the distance from such speculations to the real exhibition of the experiment itself.

Confused Ideas of Lord Bacon on Aëronautics.

Some writers have stated, that Lord Bacon first published the true principles of aëronautics. This round assertion we cannot help noticing, because it has really no foundation, except in the propensity, fostered by indolence, which would gladly refer all the discoveries ever made to a few great names. They mistake, indeed, the character of Bacon, who seek to represent him as an inventor. His claim to immortality rests chiefly on the profound and comprehensive views which he took of the bearings of the different parts of human knowledge; for it would be difficult to point out a single fact or observation with which he enriched the store of physical science. On the contrary, being very deficient in mathematical learning, he disregarded, or rejected, some of the noblest discoveries made in his own time.

We can find only two passages in Lord Bacon's works, which can be considered as referring to aëronautics; and they both occur in that collection of loose facts and inconclusive reasonings, which he has entitled *Natural History*. The *first* is styled, *Experiment Solitary, touching Flying in the Air*, and runs thus: "Certainly many birds of good wing (as kites and the like) would bear up a good weight as they fly; and spreading feathers thin and close, and in great breadth, will likewise bear up a great weight, being even laid, without tilting upon the sides. *The further extension of this experiment might be thought upon.*" This hint is not, in fairness, obnoxious to stricture, since the ingenious Bishop Wilkins, twenty years afterwards, still believed that men could acquire the art of flying. Nor was there any reason to despair, till Borelli at length demonstrated its absolute impossibility.—The second passage is more diffuse, but less intelligible: It is styled, *Experiment Solitary, touching the Flying of unequal Bodies in the Air*. "Let there be a body of unequal weight, (as of wool and lead, or bone and lead), if you throw it from you with the light end forward, it will turn, and the weightier end will recover to be forwards, unless the body be over-long. The cause is, for that the more dense body hath a more violent pressure of the parts from the first impulsion; which is the cause (though heretofore not found out, as hath been often said) of all violent motions: And when the hinder part moveth swifter (for that it less endureth pressure of parts) than the forward part can make way for it, it must needs be that the body turn over; for (turned) it can more easily draw forward the lighter part." The fact here alluded to, is the resistance that bodies experience in moving through the air, which, depending on the quantity of surface merely, must exert a proportionally greater effect on rare substances. The passage itself, however, after making every allowance for the period in which it was written, must be deemed confused, obscure, and unphilosophical.

True Theory of Balloons.

That a body must remain suspended in a fluid denser than itself, was first established by Archimedes, whose propositions in hydrostatics were farther extended in modern times by Stevinus, and other early mathematicians. But the principles on which a balloon could be made to rise in the atmosphere, were scarcely understood till very long afterwards, when chemistry, near the latter part of the last century, had succeeded in ascertaining the properties of the different kinds of aëriform substances. The Greeks of the lower empire knew that air is greatly dilated by warmth; and Sanctorio, the ingenious medical professor at Padua, by applying this expansion, about the year 1590, to the construction of the thermometer, had happily placed it in a strong light. His countryman, Borelli, remarked, almost a century afterwards, that a heated iron, or a burning taper, brought near one of the scales of a well-poised balance, by exciting a vertical current, will cause it to mount up with force;—a fact which affords the only true explication of the numerous experiments of Buffon with the weighing of red-hot balls, whose regular and constant results appeared to that eloquent philosopher to exhibit a conclusive demonstration of the actual ponderability of heat. Yet warm air, alone and unassisted, has still no very great power of ascension. The buoyancy communicated to that fluid by

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the distensible vapour of water, and other more volatile liquids, is in some cases considerable, especially when combined at the same time with heat. But those aëriform substances, which are more elastic than common air, display the most steady and powerful tendency to rise in the atmosphere. Such, in a remarkable degree, is the hydrogen gas, owing, probably, to the expansive force communicated by the very large share of heat which is embodied with it.

Lightness of Hydrogen Gas found by Cavendish.

The late most ingenious and accurate Mr Cavendish, in 1766, found, by a nice observation, this fluid to be at least seven times lighter than atmospheric air. It therefore occurred to Dr Black of Edinburgh, that a very thin bag, filled with hydrogen gas, would rise to the cieling of a room. He provided, accordingly, the allantois of a calf, with the view of showing, at a public lecture, such a curious experiment before his numerous auditors; but, owing to some unforeseen accident or imperfection, it chanced to fail, and that celebrated professor, whose infirm state of health, and cold or indolent temper, more than once allowed the finest discoveries, when almost within reach, to escape his penetration, did not attempt to repeat the exhibition, or seek to pursue the project any farther. Several years afterwards, a similar idea occurred to Mr Cavallo, who found, however, that bladders, though carefully scraped, are too heavy, and that China paper is permeable to the gas. It is rather singular that he did not think of gold-beater's skin, which had, for like purposes, been recommended, two centuries before, by the grammarian Joseph Scaliger, and some other writers. But, in 1782, this ingenious person succeeded with the pretty experiment of elevating soap-bubbles, by inflating them with hydrogen gas.

Power of Ascension.

To construct an aëronautic machine, it is only required, therefore, to provide a thin bag, of sufficient capacity, and to fill it with hydrogen gas, or with air which is kept in a rarified state. The form and strength of the material are not so essential as in Lana's project, since it here suffers an equal pressure on both its outer and its inner side. Nor is it an absolute condition that the substance of the bag should be quite impervious to the gas or confined air; though such a defect, by allowing the partial escape of the buoyant fluid, must inevitably diminish the vigour, and abridge the duration of the power of the balloon's ascent. This power is evidently the excess of the weight of an equal bulk of atmospheric air above the aggregate weight of the included gas, joined to that of the bag, and of all its appendages: In other words, the final power of ascent is the difference between the weight of the included gas and of that of an equal volume of external air, farther diminished by the weight of the whole apparatus. But, supposing the form of the balloon to remain the same, this counteracting load, as it depends on the quantity of surface contained in the bag, must be proportioned to the *square* of the diameter; whereas the difference between the internal and external volume of fluid, which constitutes the whole of the buoyant force, increases in a faster ratio, being proportioned to the capacity of the bag, or the *cube* of its diameter. It hence follows, that however small the excess may be of the specific gravity of the external air above that of the collected fluid, there must always exist some corresponding dimension which would enable a balloon to mount in the atmosphere.

The theory of aëronautics, considered in its detail, includes three distinct things: *First*, The power of a balloon to rise through the air: *Second*, The velocity of its ascent: And *Third*, The stability of its suspension at any given height in the atmosphere. These points we shall examine separately.

I. *The buoyant force of balloons.* Since balloons in their shape generally approach to the spherical form, it will be more convenient to ground our calculations on that figure. A globe of common air at the level of the sea, and of the mean density and temperature, is found to weigh about the 25th part of a pound *avoirdupois*. Consequently, if a perfect vacuum could be procured, a balloon of ten feet diameter must rise with a force of 40 pounds; one of twenty feet diameter, with that of 320 pounds; and a balloon of thirty feet in diameter would mount in the atmosphere with the power of 1080 pounds;—thus augmenting always in the ratio of the cube of the diameters. But air expands by heat about the 450th part of its bulk, for each degree on Fahrenheit's scale. Supposing, therefore, that the air included within the bag were heated 50 degrees, which is as much perhaps as could be well supported, it would follow that one-ninth part of this fluid would be driven out by the warmth, and consequently, that the tendency of the balloon to rise upwards would be equal only to the ninth part of the entire power of ascension. Were it possible to maintain a heat of 75 degrees within the balloon, the buoyant force would yet exceed not the sixth part of the absolute ascensional power.

Buoyancy of Balloons: from Heat;

The dilatation which the presence of humidity communicates to air, will, during fine weather in this climate, amount generally to one-eightieth part, though it may sometimes reach to more than the double of this quantity. But, in the tropical regions, such dilatation will commonly exceed the twentieth part of the volume of fluid. Hence moist air thrown into a bag, likewise wetted, and sufficiently large, would cause it to rise in the atmosphere. To succeed, however, in this way, the balloon constructed of coarse linen would require enormous dimensions; not less than three hundred feet in diameter.

from Humidity;

But it is the union of heat and moisture, that gives to air the greatest expansion. The white smoke with which the balloons are filled on Montgolfier's plan, was found, by computation, to be at least one-third specifically lighter than the external air. This purer sort of smoke is scarcely anything but air itself charged with vapour, being produced by the burning of chopped straw, or vine twigs, in a brazier, under the orifice of the bag. It would have required no fewer than 150 degrees of heat alone to cause the same extent of rarefaction.

from Heat joined to Moisture.

We have therefore sufficient data for calculating the buoyant force of the common fire, or rather smoke, balloons. This force, being estimated about $12\frac{1}{2}$ pounds *avoirdupois* when the diameter of the bag is ten feet, would amount to $1562\frac{1}{2}$ pounds if the diameter were fifty feet, and to 12,500 pounds if it were a hundred feet. The weight of the linen case may be reckoned at two-fifths of a pound, for a sphere

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of one foot in diameter. Consequently, a balloon of ten feet diameter would, without its appendages weigh 40 pounds; one of fifty feet diameter 1000 pounds; and one of a hundred feet diameter 4000 pounds. Such a balloon of ten feet diameter, would need $27\frac{1}{2}$ pounds to make it rise; but one of fifty feet diameter would ascend with a force of $562\frac{1}{2}$ pounds, and one of a hundred feet diameter would exert an ascending power of not less than 8500 pounds. There is besides to be deducted the weight of the cordage, the car, the ballast, and the passengers. It would require, on these estimates, a diameter of $33\frac{1}{3}$ feet, to procure merely an equilibrium between the weight of the canvas and the buoyant force of the rarified air.

The hydrogen gas obtained from the action of dilute sulphuric acid upon iron filings is only six times lighter than atmospheric air; but the gas evolved during the solution of zinc in that acid is not less than twelve times lighter than the standard fluid. The ordinary way of examining the specific gravity of the different gases requires a very delicate operation of weighing with the most exquisite balance;—a serious difficulty, which long retarded our knowledge of their comparative densities. In one of the notes to his *Treatise on Heat*, Professor Leslie has pointed out a very simple method, founded on the principles of pneumatics, for discovering the relative specific gravities of the aëriform fluids. This consists in observing the time that a given portion of the gas, under a determinate pressure, takes to escape through a very small aperture. The density of the gaseous fluid must be inversely as the square of the interval elapsed. Thus, the hydrogen gas, procured from zinc, but without any depuration, was found, under a pressure of the same column of water, to flow thrice as fast as atmospheric air. This experiment is very striking, and requires no more apparatus than a cylindrical glass jar, open below, and surmounted by a cap, terminating in a fine tubular orifice.

Balloons with Hydrogen gas.

On a very moderate supposition, therefore, and after making every allowance for imperfect operation, we may consider the hydrogen gas which fills a balloon as six times lighter than the like bulk of common air. Consequently, such a balloon must exert five-sixths of the whole buoyant force corresponding to its capacity, or will have a tendency to mount in the atmosphere, that is equal to the thirtieth part of a pound *avoirdupois* for a globe of one foot diameter. A spherical balloon of fifteen feet diameter would hence have a buoyancy of $112\frac{1}{2}$ pounds; one of thirty feet, 900 pounds; and one of sixty feet, no less than 7200 pounds. But thin silk, varnished with caoutchouc or elastic gum, to render it impervious to air, is found to weigh only the twentieth part of a pound, when formed into a globe of one foot diameter. A silk balloon of fifteen feet diameter would hence weigh $11\frac{1}{4}$ pounds; one of thirty feet diameter, 45 pounds; and one of sixty feet diameter, 180 pounds. Wherefore, the power of ascension exerted by such balloons would, in pounds *avoirdupois*, be respectively $101\frac{1}{4}$, 855, and 7020. It follows, also, that a balloon of a foot and a half in diameter would barely float in the atmosphere, the weight of its varnished silk being then exactly balanced by the buoyant effort of the body of hydrogen gas.

But the calculations now given would, in strictness, require a small modification. The weight of the bag and of all the appendages, must evidently compress the included gas, and thereby render it in some degree denser. To compute this minute effect, we have only to consider, that the pressure of a column of atmosphere, at the mean temperature, and near the level of the sea, is 1632 pounds, on a circle of a foot diameter. Thus, in the large balloon of sixty feet diameter, if we suppose the whole load to have been 6000 pounds, the compression of the bag would only amount to five-thirds of a pound, for each circle of a foot diameter in the horizontal section, or correspond to the 979th part of the entire pressure of the atmosphere. But the weight of the confined gas being 1200 pounds, its buoyancy must have suffered a diminution of somewhat more than a pound, or $1\frac{7}{31}$, from the incumbrance opposed to it. This correction is therefore a mere theoretical nicety, which may be totally disregarded in practice.

Celerity of the Ascent of Balloons.

II. The next circumstance to be considered in aëronautics is *the celerity with which balloons make their ascent.* It is obvious that the efficient power of ascension, or the excess of the whole buoyant force above the absolute weight of the apparatus, would, by acting constantly, produce always an accelerated motion. But this acceleration is very soon checked, and a uniform progress maintained, by the increasing resistance which the huge mass must experience in its passage through the air. The velocity which a balloon would gain from unobstructed acceleration, must, from the theory of dynamics, be to that which a falling body acquires in the same time, as the efficient buoyancy is to the aggregate weight of the apparatus and of the contained fluid. Thus, if the balloon were to rise with a force equal to the eighth part of its compound weight, the celerity resulting from a constant acceleration, would be expressed, by multiplying four feet into the number of seconds elapsed since it was launched into the air. Its accelerating advance, however, being opposed, the balloon may, to all appearance, attain, though still affected with partial oscillations, the final velocity in perhaps little more than double the time required without such obstruction.

Terminal Velocity.

This final velocity, or the velocity at which the ascent becomes uniform, the resistance from the air being then equal to the efficient buoyancy of the balloon, is easily calculated. The resistance a circle encounters in moving through any fluid in the direction perpendicular to its plane, is measured by the weight of a column of that fluid, having the circle for its base, and an altitude equal to the height from which a heavy body in falling would acquire the given celerity. But near the level of the sea, and at the mean temperature, a column of atmospheric air 17 feet high, and incumbent on a circle of one foot diameter, weighs a pound *avoirdupois*; which is therefore the resistance that such a circle would suffer, if carried forwards with the celerity of 33 feet each second. According to the same theory, however, which we owe to the sagacity of Newton, the resistance of a sphere is just the half of that of its generating circle, and consequently a velocity of $46\frac{2}{3}$ feet

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in a second through the air would, in ordinary cases, create a resistance of one pound to a ball of one foot diameter. In other circumstances, the quantity of resistance must be proportional to the squares of the velocities and of the diameters. Whence, if the buoyant force were always the same, the velocity of the ascent of a balloon would be inversely as its diameter.

Example. General Formula.

Suppose a balloon to have thirty feet in diameter, and an ascensional power of 100 pounds. This effort is evidently the same as the ninth part of a pound for a globe of a foot diameter, and would therefore be countervailed by the resistance corresponding to a velocity of $46\frac{2}{3}$ divided by 3, the square root of 9, or $15\frac{5}{9}$ feet each second. The balloon would therefore reach the altitude of a mile in about six minutes. Its accelerating force being only the sixteenth part of its total weight, it might have acquired the uniform motion of ascent in twenty seconds, or before it had attained the height of 200 feet. This example differs very little from reality, and the method of computation will easily be transferred to other cases.

But the resistance of the air assigned by theory is, from the circumstances omitted in the simplification of the problem, generally somewhat less than the results of observation. In low velocities, this difference amounts seldom to the fifth part of the whole effect; but, in the high velocities, it increases considerably, exceeding even the third part, in certain extreme cases. From the numerous and accurate experiments of Dr Charles Hutton, we may, however, deduce a simple formula, for expressing the terminal velocity of balloons, or the celerity of their uniform ascent. Let $a$ denote the diameter of the balloon, in English feet, and $f$ its ascensional power, measured in pounds *avoirdupois*; then $\frac{40}{a}\sqrt{f}$ will very nearly represent, in feet, the velocity each second of its regular ascent, or that velocity which would cause a resistance from the air, precisely equal to the buoyant force. Or, to express the rule in words: As the diameter of the balloon in feet is to the constant number 40, so is the square root of the ascensional power in pounds to the terminal, or uniform velocity of ascent each second. To illustrate the application of the formula by an easy example; suppose the balloon to have a diameter of 60 feet, with an accelerating power of 144 pounds; the corresponding rate of uniform ascent becomes $\frac{40}{60}\sqrt{144}$, or $\frac{2}{3}\times 12$, that is, 8 feet each second, or about a mile in eleven minutes.

Stability of Suspension.

III. The last point which demands attention in aëronautics is, *The stability of the suspension of a balloon at any given height in the atmosphere.* The circumstances which might regulate or determine that stability, requiring some little exercise of thought, have been commonly neglected, and very seldom examined with due care. It will be proper to consider, *first*, the fire or smoke balloons, and *second*, the balloons filled with hydrogen gas.

Smoke Balloons.

1. The warm humified air of the balloon constructed after Montgolfier's plan, suffering less external compression as it approaches the upper strata of the atmosphere, must at the same time necessarily expand, and partly escape by the orifice above the brasier. The weight of the included fluid, and that of the part expelled, constituting its buoyant force, will hence be reduced, in proportion to the diminished density of the medium in which it floats. The balloon will continue to ascend, till its enfeebled buoyancy is no longer able to support the incumbent load. At the height of a mile above the surface, the power of ascension would be diminished rather more than one-fifth part, but, at an altitude of three miles and a half, it would be reduced to one-half. At the ordinary temperature, this buoyancy would suffer a reduction of the hundredth part, for each ascent of 278 feet. Resuming the data formerly stated, and supposing the balloon to have a spherical shape; its actual power of ascension, estimated in pounds avoirdupois, will be denoted by $\frac{a^3}{80}$, where $a$ signifies the diameter in feet; or the cube of the diameter divided by the constant number 80. If $m:n$ express the ratio of atmospheric density at the surface, and at any given height; then will $\frac{n}{m}\cdot\frac{a^3}{80}$ denote the diminished buoyant force at that altitude.

We shall select, for example, a balloon of 100 feet diameter, which is one of the largest dimensions ever actually constructed. Near the level of the sea, and at the ordinary temperature, its power of ascension would be 12,500 pounds; but, at the height of 8000 feet, or somewhat more than a mile and a half, when the density is diminished one-fourth, or $\frac{n}{m}=\frac{3}{4}$, that power becomes reduced to $\frac{3}{4}\times 12,500$, or 9375 pounds, being a deficiency of 3125 pounds. On the supposition that the balloon was at first so much loaded as to rest just suspended at the ground, a ballast of 3125 must have been thrown out, to make it rise to the altitude of a mile and a half. Hence, also, the rejection of 125 pounds would have been sufficient to give the balloon an elevation of 278 feet. For the same reason, 10 pounds of ballast heaved out would raise it 22 feet at the surface, 29 feet at the height of a mile and a half, and 44 feet at that of three miles and a half.

Balloons charged with Hydrogen Gas.

2. The stability of the suspension of balloons filled with hydrogen gas must depend on principles which are very different, and less marked. In these aëronautic machines, after the gas has been once introduced, it is closely shut up; and, therefore, having constantly the same absolute weight, it should likewise, in all situations, exert the same buoyant force. Hence, if the balloon were capable of indefinite extension, it would still continue its ascent through unbounded space. The determinate capacity of the bag alone can oppose limits to its rise in the atmosphere. The upper strata being rarer than those below, will have less power to keep any given bulk suspended; and the actual buoyancy, being diminished from that cause, the balloon will find its station at a corresponding height in the diffuse medium. But

this diminution of the buoyant force, and the consequent increase in the density of the hydrogen gas, must necessarily be confined within very moderate limits, otherwise the thin silk case would be torn to shreds by the expansive efforts of the imprisoned fluid. A safety-valve is accordingly placed at the top of the balloon, calculated to give vent to the gas, before the distention has become such as to endanger the bursting of the case.

should not be completely filled;

A balloon should not at first be filled completely with hydrogen gas, but allowed to begin its ascent in rather a flaccid state. As it mounts into the rarer atmosphere, it will gradually swell, till it has attained its full distention, when the safety valve may come to act. But such dissipation of the gas ought, by a previous arrangement, to be as much as possible avoided. If the balloon were intended to rise to the height of four miles, it would not be requisite to fill more than half its capacity with the elastic fluid. To push the charge any farther in this case, would only occasion a superfluous waste of materials. By throwing out part of his ballast, the aëronaut may raise himself higher, and by opening the valve to permit some of the imprisoned gas to escape, he may descend again; but both those expedients are attended by a wasteful expenditure of power.

unstable when flaccid.

It is evident that a balloon can have no stability of equipoise, so long as it remains in a loose or flaccid state. The slightest action would then be sufficient to make it rise or fall, since, under such circumstances, any change of its station could not in the smallest degree affect the measure of its buoyant force. The general elevation to which the balloon will ascend, must be determined by its quantity of ballast, conjoined with the regulation of the safety-valve; but the strain of the silk case itself would be sufficient to confine the ascent within certain limits, and to procure the stability of the floating mass. Thus, if a balloon, fully distended, had yet a slight disposition to rise, the imprisoned gas, suffering more and more compression as it gradually ascends, would become proportionally denser, and therefore lose a corresponding part of its previous buoyancy. An equilibrium would hence soon obtain, which must arrest the floating machine at a determinate height in the atmosphere.

Mode of adjusting Balloons.

Suppose a balloon to be capable, without any danger of bursting, of sustaining an expansion equal to the hundredth part of the elasticity of the included fluid; the whole buoyancy would, by such an alteration, be diminished one five hundredth part, or this floating machine would subside 55 feet near the surface, and sink proportionally more in the upper regions. To produce the effect, it would only be requisite to throw common air into the bag, without suffering any portion of the hydrogen gas to escape. On this principle, Meûnier, an ingenious French chemist, very soon after the first discovery of balloons, proposed to regulate, with nicety, their ascent and position of equilibrium in the atmosphere. The mode which he suggested, was to place within the principal balloon a much smaller one, to be filled occasionally with common air by help of bellows, or emptied again by opening an exterior valve. The aëronaut would thus have it in his power, without expending the charge of hydrogen gas, either to sink gently through a short space, or to rise again at will, by inflating the inner balloon, or allowing it to collapse. The adjustment of the height of a balloon could hence be managed with great precision.

The command possessed by the aëronaut of raising or depressing his machine at pleasure, might afford him the means of influencing the direction of its course. From the various motions of the several ranges of clouds, we may infer that different currents exist at the same time in the atmosphere. The aëronaut has, therefore, in his ascent, only to seek the current best suited to his purpose, and, taking his station in that stratum, to commit his flimsy vessel to the guidance of the stream.

Futility of applying Sails or Rudders.

Any other attempts to direct or controul the flight of a balloon, are altogether fallacious. Since it is carried along with the swiftness of the wind, no rudders or sails can have any action whatever. The aëronaut might fancy himself to float in a perfect calm, unless he chances to encounter irregular currents. The application of oars may turn a balloon, but can have no sensible effect in diverting or impelling its course. How vastly disproportionate is the force of the human arm to the overwhelming pressure of the wind against so huge a machine! To adapt machinery under these circumstances would be preposterous, and to look for help from such a quarter is visionary in the extreme. It must be admitted, however, that after a balloon has once gained its station of equilibrium, or passively floats in the air, the vigorous action of broad vanes, downwards or upwards, might serve to raise or depress the machine through a small space. Thus, a vertical force, exerted equal to nine pounds, would lift a balloon, of thirty feet in diameter, 278 feet higher. The application of ballast is hence infinitely preferable to any such bulky and unmanageable apparatus.

At the period where we left our narrative, the principles on which a balloon could be constructed, were therefore pretty generally known to men of science. But to reduce these principles to complete effect, was still an enterprize of the most dazzling kind. This experiment seemed unfit for a cabinet or a laboratory, and it could succeed only on a large scale, exposed to the gaze of the multitude. Without the toil of investigation, or indeed any exercise of thought, all the world might witness the result, and admire the magnificent spectacle which it would present. This triumph over matter was at length achieved by the skill and perseverance of Stephen and Joseph Montgolfier, sons of the proprietor of an extensive and very celebrated paper manufactory established at Annonay, on the banks of a rivulet which flows into the Rhône, near forty miles below Lyons. These remarkable persons, though bred in a remote provincial town, possessed, in a high degree, ingenuity and the spirit of observation. Without having the benefit of a liberal education, their active curiosity had led them to acquire a more extensive and accurate stock of knowledge than is usually found in the same condition of life. Stephen was more attached to mathematics, but Joseph directed his studies chiefly to chemistry and natural philosophy. They were asso-

The Montgolfiers actually discover the Balloon.

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ciated in business with their father, who passed his quiet days, like a patriarch, amidst a large family, and a numerous body of workmen, and reached the very advanced age of 93. Of the younger brother, who survived the other, and lived to make the very valuable, yet much neglected, discovery of the Hydraulic Ram, we may venture to speak from personal acquaintance. He was a man of great modesty and simplicity of character, yet firm and undaunted, of a calm and sedate aspect, tall and athletic in his person, and of a swarthy complexion, not unlike the celebrated Mr Watt, whom he resembled in some other particulars of his fortune. He was too speculative, perhaps, to succeed in the details of business, for, after trying various schemes of improvement, he quitted his paper manufactory and repaired to the capital, where he obtained a situation of trust under the late Imperial government, at the Chamber of Models, as inspector of patents and internal improvements. In 1809 he had a stroke of palsy, which induced him to resort to the waters of Bourbonne; but receiving no benefit from them, he gladly preferred those of Balaruc, near his old friends, where he died on the 26th of June in the following year, at the age of 60.

Their successive Experiments.

The two brothers, who were accustomed to form their plans in concert, had long contemplated the floating and ascent of clouds in the atmosphere. It seemed to them, that a sort of factitious cloud, formed of very thin vapour, inclosed in a light bag of immense size, would mount to the higher regions. In pursuit of this idea, they selected a fluid specifically lighter than atmospheric air; and, accordingly, introduced hydrogen gas into large bags of paper and of thin silk, which rose up, as had been expected, to the cieling, but fell down in a few seconds, owing to the rapid escape of the gas through the cracks and pores of the case. This great facility with which hydrogen gas makes its way through any substance of a loose and incompact texture, is partly due to its extreme fluidity, but is chiefly occasioned by its strong and obstinate attraction for common air. The mode of preventing or at least checking that escape, by the application of a proper varnish, was yet unknown. The prospect was so discouraging, that our experimenters had recourse to another scheme, more analogous to their original ideas, and it rewarded their continued efforts with the most complete success. In the month of November 1782, Joseph Montgolfier, happening, in the course of his frequent excursions, to be then at Avignon, procured a small silk bag, of the form of a parallelopipedon, open below, like a lady's hoop, and having a capacity of about forty-five cubic feet; under its orifice he burnt some paper, and saw, with inexpressible transport, the bag quickly swell, and mount rapidly to the height of seventy-five feet, where it remained, till by cooling it lost its buoyancy. Returning to Annonay, he communicated the happy result to his brother, and it was resolved by them to prosecute the experiment on a larger scale. Having provided a large quantity of coarse linen, they formed it into the shape of a globe, about thirty feet in diameter, which they lined with paper. On lighting a fire within its cavity, to warm and expand the air, they had the delightful satisfaction of seeing the bag ascend, with a force equivalent to 500 pounds.

It was very natural, that the brothers should now desire an occasion, for exhibiting this grand experiment in their native town. They invited the members of the provincial meeting of the States of the Vivarais, then assembled at Annonay, to witness the first public aërial ascent. On the 5th June 1783, amidst a very large concourse of spectators, the spherical bag or balloon, consisting of different pieces of linen, merely buttoned together, was suspended from cross poles; two men kindled a fire under it, and kept feeding the flames with small bundles of chopped straw; the loose bag gradually swelled, assuming a graceful form, and, in the space of five minutes, it was completely distended, and made such an effort to escape, that eight men were required to hold it down. On a signal being given, the stays were slipped, and the balloon instantly rose with an accelerating motion, till it reached some height, when its velocity continued uniform, and carried it to an elevation of more than a mile. All was admiration and transport. Amidst the shouts of unbounded acclamation, the progress of the artificial cloud retiring from sight arrested every eye. It was hurried along by the wind; but, its buoyant force being soon spent, it remained suspended only ten minutes, and fell gently in a vineyard, at the distance of about a mile and a half from the place of its ascension. So memorable a feat lighted up the glow of national vanity, and the two Montgolfiers were hailed and exalted by the spontaneous impulse of their fellow-citizens.

First public Ascent of a Balloon.

The Impression made by it in Europe.

Of this splendid experiment, a very hasty and imperfect account was transmitted to Paris, and quickly circulated over Europe. In those halcyon days, during the transient calm of political turmoils, and the happy absence of all military events, the prospect of navigating the atmosphere excited a very general ferment, and engrossed the conversation of all ranks. Yet the tale appeared so extraordinary, as to leave some doubts of its veracity. In many places, and especially in this country, the more ignorant class of men, and those who affected superior wisdom, both agreed in considering the relation of Montgolfier's discovery as nothing but an imposition practised on the public credulity. To dispel the suspicions which infected the subject, it was necessary to repeat the experiment in every large capital.

When the intelligence of the first ascent of a balloon reached St Petersburgh, it found the venerable Euler in a state of great debility, worn out with years and unremitting intellectual toil. Having lost, in the middle of his career, the sight of an eye, he had been, for several years, visited with total blindness. But, in this afflicting situation, his mind was still entire, and found delightful exercise in his former habits of calculation. It was in training a domestic to act as his amanuensis, that this great genius now condescended to dictate, in the German language, to his humble pupil, a work of the highest merit,—*The Elements of Algebra*. During his last illness, Euler made an expiring effort, and applied his favourite analysis to determine the ascending motion of a bal-

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loon. He dictated the preliminary steps of the problem to one of his grandchildren; but the hand of death was already stretched over the patriarch;—no farther could he proceed with his investigation;—and composing himself for nobler scenes, he calmly expected the moment of dissolution.

Imitated at Paris.

The virtuosi at Paris were eager to repeat the experiment of the ascension of a balloon. M. Faujas de St Fond, an active and zealous naturalist, set on foot a subscription for defraying the expence, which was soon filled up. The construction of the machine was entrusted to the skill of two brothers of the name of Robert, under the superintendence of M. Charles, an ingenious lecturer in natural philosophy. It had at first been proposed merely to copy the process of Montgolfier, but Charles preferred the application of hydrogen gas; a resolution which afterwards occasioned much difficulty and delay. The balloon consisted of thin silk or tiffany, varnished with a solution of elastic gum, disposed into a globular shape, of about thirteen feet in diameter. The hydrogen gas was procured from the action of dilute sulphuric acid upon iron-filings, and was introduced through leaden pipes. But this gas, being rapidly formed, without having been made to pass through a body of cold water, entered the cavity of the balloon excessively hot, and charged with acid fumes, which afterwards condensed against the inside of the bag, injuring its texture, and loading it with superfluous humidity. Not fewer than 500 pounds of sulphuric acid were used, and twice this weight of iron filings. Yet several days were spent in abortive attempts to fill the balloon completely. At last it rose, and was kept suspended at the height of 100 feet above the ground. In this state, it was conveyed with acclamations to the Place des Victoires, where it rested, and underwent some repair. About midnight, it was thence transported in silent procession, preceded by torch lights, and guarded by a detachment of horse and foot soldiers, to the Champ de Mars, at the distance of near two miles. The few passengers found at that still hour on the streets, gazed with astonishment at the floating mass, and the very coachmen, filled with a sort of awe, respectfully saluted it as they passed.

Balloon of Charles and Robert.

Next day, being the 27th of August 1783, an immense concourse of people, covered the Champ de Mars, and innumerable spectators had planted themselves along the banks of the Seine and the amphitheatre of Passy. By three o'clock, every avenue was filled with carriages, and all the beauty and fashion of Paris flocked towards the Ecole Militaire. The preparations being finished, a cannon was discharged, as the signal of ascent. The balloon, liberated from its stays, shot upwards with such rapidity, as in two minutes to reach, according to calculation, the height of 3000 feet, where it seemed lost in a dark cloud; it re-appeared at a greater elevation, but was soon obscured again amidst other clouds; and after performing a flight of about fifteen miles, in the space of three quarters of an hour, it sunk to the ground in a field near Ecouen, where the peasants secured it, having noticed a rent in the upper part of the bag, to which its fall might be imputed. The success of the experiment was complete. The incredulous were sadly mortified; but every minor reflection was drowned in the tumult of excessive joy and exultation. It began to rain immediately after the balloon was launched, yet this unlucky circumstance had no effect to abate the curiosity of the spectators. Regardless of the torrents that fell, they were wholly absorbed, in following with eager gaze the progress of the machine through the air. Even elegant ladies, dressed in their finest attire, stood exposed, looking intently the whole time, and were drenched to the skin. This small balloon weighed only thirty pounds, and had at first a buoyant force of forty pounds *avoirdupois*. If we employ the formula before given, the terminal velocity would be $\frac{40}{13}\sqrt{40} = 19\frac{6}{13}$ feet in a second, or 1168 feet each minute; which appears to correspond very well with fact.

Joseph Montgolfier constructs one of his Balloons at Paris.

About this time, Joseph Montgolfier visited Paris, and was invited by the Royal Academy of Sciences, to repeat his experiment of Annonay on a larger scale. He constructed, with coarse linen and a paper lining, a balloon of a pear shape, and about forty-three feet wide and seventy-five feet high. The smoke of fifty pounds of dry straw, in small bundles, joined to that of twelve pounds of wool, was found sufficient to fill it, in the space of ten minutes. The bag duly swelled, and made an effort to rise, equivalent to the weight of 500 pounds; but being reserved for exhibition the next day, it was totally destroyed, by its exposure, during the night, to incessant and violent rain. It became necessary, therefore, to prepare another balloon, and such was the expedition of the artist, that in five days he got the whole completed. Early on the morning of the 19th of September, it was placed upon an octagon scaffold, in front of the palace of Versailles. It had a very showy appearance, being painted with ornaments in oil colours. By ten o'clock, the road from Paris was crowded with carriages of all descriptions. Every person of any note or fashion, hurried from the metropolis to view the experiment; ladies of distinguished rank filled the windows; and the spacious courts and walks, and even the tops of the houses, were covered with impatient spectators. The royal family and their attendants came forth, and examined the details of the apparatus. About one o'clock, the discharge of a mortar gave notice that the filling of the balloon was to commence. In eleven minutes, another discharge announced, that it was completely inflated; and on the third discharge of the mortar, the cords were cut, and the balloon instantly liberated. After balancing at first in a moment of anxious expectation to the spectators, it rose majestically, in an oblique direction, under the impulse of the wind, till it reached the height of 1500 feet, where it appeared for a while suspended, but in the space of eight minutes it dropped to the ground, at the distance of two miles from the point of its ascent. A sheep, a cock, and a duck, which had been put into the basket, the first animals ever carried up into the air, were found perfectly safe and unhurt by the journey, and the sheep even feeding at perfect ease.

This successful experiment encouraged Montgolfier to prepare, on a more solid construction, another balloon, of a spheroidal form, 45 feet wide, and 75

feet high. While it was filling with smoke, Pilatre de Rozier, a young naturalist, of great promise, and full of ardour and courage, leaped into the car, and was borne up to the height of 300 feet, where he continued some minutes suspended, the balloon being held down by long cords till it gently descended. The dangers of navigating the balloon being thus brought to a more correct estimate, it was resolved speedily to attempt the daring but sublime experiment. The badness of the weather, however, at this late season of the year, made the project be deferred several days. At last, on the 21st of November, every thing was ready for the ascent in the spacious gardens of the chateau of Muette, belonging to the court of the Dauphin. The sky had a lowering aspect, being loaded with heavy clouds, driven about by irregular winds. But the adventurers were not to be easily discouraged.

Makes the first aërial Voyage.

After a first trial, which had nearly proved fatal to them, the balloon was again filled; and Rozier, with the Marquis d'Arlandes, a major of infantry, who had volunteered to accompany him, took their seats in the car, having a store of ballast, and a provision of straw to supply the fire. About two o'clock, the machine was launched, and it mounted with a steady and majestic pace. Wonder, mingled with anxiety, was depicted in every countenance; but when, from their lofty station in the sky, the navigators calmly waved their hats, and saluted the spectators below, a general shout of acclamation burst forth on all sides. As they rose much higher, however, they were no longer discernible by the naked eye.

——————in the surging smoke
Uplifted spurn the ground; thence many a league,
As in a cloudy chair ascending, ride
Audacious.——————

This balloon soared to an elevation of more than 3000 feet, and traversed, by a circuitous and irregular course, the whole extent of Paris, whose gay inhabitants were all absorbed in admiration and amazement. A curious circumstance occurred during the passage of the floating mass: To the gazers planted on the towers of the metropolitan church of Notre Dame, it chanced to intercept the body of the sun, and thus gave them, for a few seconds, the spectacle of a total eclipse.—It has been alleged, that when the balloon had reached so high, that the objects on earth were no longer distinguishable, the Marquis d'Arlandes began to think that his curiosity and ambition were sufficiently gratified. He was therefore anxious to descend, and murmured against his companion, who still kept feeding the fire. At last, on hearing some cracks from the top of the balloon, and observing holes burning in the sides, the Major became outrageously alarmed at his imminent danger, and applying wet spunges to stop the progress of combustion, he compelled the *savant* to desist from his officious operations. As they now descended too fast, however, M. d'Arlandes was not less anxious and diligent in throwing fresh straw upon the fire, in order to gain such an elevation, as would clear the different obstacles. The navigators dexterously avoided the lofty buildings of Paris, by supplying fuel as occasion required; and, after a journey of 20 or 25 minutes, they safely alighted beyond the Boulevards, having described a track of six miles.

Such was the prosperous issue of the first aërial navigation ever achieved by mortals. It was a conquest of science which all the world could understand; and it flattered extremely the vanity of that ingenious people, who hailed its splendid progress, and enjoyed the honour of their triumph. The Montgolfiers had the annual prize of six hundred livres adjudged to them by the Academy of Sciences; the elder brother was invited to Court, decorated with the badge of St Michael, and received a patent of nobility; and on Joseph a pension was bestowed, with the further sum of forty thousand livres, to enable him to prosecute his experiments with balloons.

The facility and success, however, of the smoke, or fire balloons, appeared to throw into the shade the attempts made by the application of hydrogen gas. M. Charles, the promoter of this plan, was keenly reproached by M. Faujas de St Fond, for departing from the method practised by the original inventor; and he was moreover, with his associates the Roberts, held up to public derision in the smaller theatres of Paris. To silence the cavils and insinuations of his antagonists, he resolved, therefore, on making some new efforts.

New Balloon of Charles and the Roberts.

A subscription was opened to defray the expence of a globe twenty-eight feet in diameter, and formed of tiffany, with elastic varnish. After repeated accidents and delays, this balloon was planted, on the 1st of December 1783, at the entrance of the great alley of the Tuilleries, and the diffuse fluid was this time introduced into it from a sort of gazometer. The dilute sulphuric acid and the iron filings being put into wooden casks, disposed round a large cistern, the gas was conveyed in long leaden pipes, and made to pass through the water under a glass bell plunged in it. The whole apparatus cost about L. 400 Sterling, one half of which was expended on the production of the gas alone. An immense concourse of spectators had collected from all parts. The discharge of a cannon at intervals announced the progress in filling the balloon. To amuse the populace, and quiet their impatience, M. Montgolfier was desired to let off a small fire-balloon, as a mark of his precedence. At last, the globe being sufficiently inflated, and a quantity of ballast, consisting of small sand bags, lodged in the car, leaving only $22\frac{1}{2}$ pounds for the measure of the buoyant force, MM. Charles and Robert placed themselves in the appended boat or car, and the machine was immediately disengaged from its stays.

Their Ascent.

It mounted with a slow and solemn motion. According to the formula given, the terminal velocity of ascent must have been only about 400 feet each minute, or at the rate of somewhat less than five miles in the hour. "The car, ascending amidst profound silence and admiration," to borrow the warm and exaggerated language of the reporter, "allowed, in its soft and measured progress, the bystanders to follow with their eyes and their hearts two interesting men, who, like demi-gods, soared to the abode of the immortals, to receive the reward of intelligence, and carry the imperishable name of Montgolfier. After the globe had reached the height of 2000 feet, it was no longer possible to distinguish the aërial navigators; but the coloured pennants which they waved in the air testified their safety and their tranquil feelings. All

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fears were now dissipated; enthusiasm succeeded to astonishment; and every demonstration was given of joy and applause." The balloon, describing a tortuous course, and rising or sinking according to the fancy of its conductors, was, after a flight of an hour and three quarters, made to alight on the meadow of Nesle, about twenty-five miles from Paris. For the space of an hour, the buoyancy of the machine had been sensibly augmented, by the sun's rays striking against the surface of the bag, and heating up the contained gas to the temperature of 55 degrees by Fahrenheit's scale.

After this prosperous descent, the globe, though become rather flaccid and loose by its expenditure, yet still retained a great buoyant force, when relieved from the weight of the travellers. The sun had just set, and the night was beginning to close; but M. Charles formed the resolution of making alone another aërial excursion. His courage was rewarded by the spectacle of one of the most novel and enchanting appearances in nature. He shot upwards with such celerity, as to reach the height of near two miles in ten minutes. The sun rose again to him in full orb; and, from his lofty station in the heavens, he contemplated the fading luminary, and watched its parting beams, till it once more sunk below the remote horizon. The vapours rising from the ground collected into clouds, and covered the earth from his sight. The moon began to shine, and her pale rays scattered gleams of various hues over the fantastic and changing forms of those accumulated masses. This scene had all the impressive solemnity of the true sublime. No wonder, that the first mortal eye that ever contemplated such awful grandeur could not refrain from shedding tears of joy and admiration. The region in which M. Charles hovered was now excessively cold; and as he opened the valve occasionally during his ascent, to prevent the violent distention of the balloon, the hydrogen gas, not having time to acquire the temperature of the exterior air, rushed out like misty vapour, with a whistling noise. But prudence forbade the voyager to remain long at such an elevation, while darkness was gathering below. He therefore descended slowly to the earth, and, after the lapse of 35 minutes, alighted near the wood of Tour du Lay, having, in that short interval, travelled about nine miles.

Ascent of Charles alone.

This balloon, with its passengers and ballast, weighed at first 680 pounds; but, notwithstanding the care taken in filling it, the hydrogen gas must have been mixed with a large proportion of common air, since it was only $5\frac{1}{4}$ times lighter than this fluid. The barometer, which stood at 29.24 English inches at the surface of the ground, subsided to 20.05 at the greatest elevation to which M. Charles had reached. This gives, by calculation, an altitude of 9,770 feet. The thermometer, which was at 41° by Fahrenheit's scale at the first ascent, fell to 21° at the highest flight; giving a difference of one degree for every $488\frac{1}{2}$ feet of ascent.

Ascent of Montgolfier at Lyons.

The next voyage through the air was performed in the largest balloon ever yet constructed. The elder Montgolfier had been persuaded to open a subscription at Lyons for the sum of L. 180 Sterling, to construct an aëronautic machine, capable of upholding a great weight, and of carrying a horse, or other quadruped. It had an elongated shape, 109 feet wide, and 134 feet high, and was formed of two folds of linen, having three layers of paper laid between them, and quilted over with ribbands. It showed at first enormous buoyant power. A truss of straw, moistened with spirit of wine, was found, when set on fire, to yield humid smoke sufficient to inflate the balloon, and the burning of five pounds weight of alder faggots kept it in full action. Though loaded with a ballast of eighteen tons, it yet lifted up six persons from the ground. Unfortunately, it was very much damaged one night, in consequence of being exposed to rain, frost, and snow. However, on the 19th of January 1784, the balloon was charged in seventeen minutes, by the combustion of 550 pounds of alder. Joseph Montgolfier, accompanied by the ardent Pilatre de Rozier, and four other persons of note, with the proper ballast, took their seats in a wicker gallery, and were launched into the atmosphere. They manœuvred over the city of Lyons, and near the course of the Rhine, for the space of forty minutes; but a large rent having been observed in the upper part of the balloon, they were compelled to descend abruptly, though without any farther accident.



The difficulties and dangers of aërial navigation being at length surmounted, the ascents of balloons were now multiplied in all quarters. It will, therefore, be sufficient, henceforth, to notice very succinctly some of the more distinguished attempts of that kind.

Andreani.

The Chevalier Paul Andreani of Milan had a spherical balloon, of 70 feet in diameter, formed after Montgolfier's plan, at his own charge, in which, accompanied by two companions, he ascended from that capital on the 25th February, 1784. The machine rose to the height of 1300 feet; but after having described, in twenty minutes, a very circuitous track, it settled upon a large tree, from which, however, the voyagers, by applying fresh fuel, extricated themselves, and alighted on clear ground, without receiving any hurt.

Blanchard.

On the 2d of March, Blanchard, who had been, for some years before, occupied with the chimerical project of flying in the air, and who fancied that the same principles and contrivances might be applied to direct the motion of balloons, mounted alone, and with great intrepidity, at Paris, in a silk balloon, 40 feet in diameter, constructed by subscription, and filled with hydrogen gas. He darted rapidly to the height of above a mile, and after being driven about by cross winds for an hour and three quarters, he descended in the plain of Billancourt.

Fleurant and Thibl

On the 28th of June in the same year, an ascent was made at Lyons before the King of Sweden, who then travelled under the name of Count Haga, with a fire-balloon, having somewhat of a pear shape, and 75 feet in height. Two passengers, M. Fleurant and a young lady, Madame Thiblé, the first female that ever adventured on such a daring voyage, entered the car, and ascended with great velocity. In four minutes the noise of the multitude was no longer audible, and in two more the eye could not distin-

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guish them. It was inferred, from a trigonometrical calculation, that they reached the altitude of 13,500 feet. Their flag, with its staff of 14 pounds weight, being thrown down, took seven minutes to fall to the ground. The thermometer had dropt to 43° on Fahrenheit's scale; and to the sensation of cold which they felt was joined that of a ringing in the ears. Different currents were found to occupy distinct strata of the atmosphere; and in passing from one stratum to another, the balloon was affected by a sensible undulation. The travellers continued to feed their fire with the loppings of vines, till this provision being nearly spent, they safely alighted in a corn-field, having traversed about six miles in three quarters of an hour.

Rozier and Proust.

About a fortnight afterwards, the same prince was gratified by a more splendid ascent, commanded for his entertainment by the French monarch. A large fire-balloon, carrying the naturalists, Rozier and Proust, was launched from the outer court of Versailles. It soared to the height of 12,520 feet, and might appear to float in a vast congregation of extended and towering white clouds. The thermometer stood at 21° of Fahrenheit, and the flakes of snow fell copiously on the voyagers, while it only rained below. Descending again from that chaotic abyss, they were charmed with the lively aspect of a rich and populous district. They alighted at the entrance of the forest of Chantilly, about thirty-six miles from Versailles, after a flight of an hour and five minutes.

We omit the relation of a prosperous ascent performed at Rhodés, on the 6th of August, by the Abbé Carnus and his companion, with a fire-balloon, of a globular shape, and 57 feet in diameter.—The longest aërial journey yet made was accomplished at Paris, on the 19th of September. The Duke de Chartres, afterwards Orleans and the noted Egalité, employed Roberts to construct for him a silk balloon, which should be filled with hydrogen gas. It had 56 feet in height, and 36 feet diameter, being composed of a cylinder, terminated by two hemispheres; a construction which was rightly supposed to give much additional solidity to the machine. A small bag, on Meusnier's plan, had been introduced within it, and the boat was, besides, furnished with a helm and four oars. This balloon, bearing the Duke himself, the two artists, and another companion, and having 500 pounds of ballast, was allowed to rise very slowly, with a buoyancy of only 27 pounds. At the height of 1400 feet, the voyagers perceived, not without uneasiness, thick dark clouds gathering along the horizon, and threatening the approach of a thunder-storm. They heard the distant claps, and experienced something like the agitation of a whirlwind, although they had felt not the slightest concussion in the air from the discharge of cannon. The thermometer suddenly dropped from 77° by Fahrenheit to 61°; and the influence of this cold caused the balloon to descend within 200 feet of the tops of the trees near Beauvais. To extricate themselves, they now threw out more than forty pounds of ballast, and rose to an elevation of 6000 feet, where it was found that the confined gas had so obstinately retained its heat, as to be no less than 42° warmer than the external air.

Duke of Orleans.

The Duke became alarmed, and betrayed such impatience to return again to the earth, that he is said to have pierced the lower part of the silk bag in holes with his sword. After narrowly escaping the dangers from wind and thunder, the balloon at last descended in safety near Bethune; having performed a course of 135 miles in the space of five hours.

Guyton-Morveau.

On the 25th of April, in the same year, the celebrated chemist, Guyton-Morveau, with the Abbé Bertrand, ascended from Dijon in a balloon, nearly of a globular shape, twenty-nine feet in diameter, composed of the finest varnished tiffany, and filled with hydrogen gas. They did not start till five o'clock in the evening, the barometer being at 29.3 inches, and the thermometer at 57° on Fahrenheit's scale; and, after surmounting some accidents, they rose to an altitude of 10,465 feet, or very nearly two English miles, where the barometer had sunk to 19.8 inches, and the thermometer to 25°. They felt no inconvenience however, except from the pinching of their ears with cold. They saw an ocean of clouds below them, and in this situation they witnessed, as the day declined, the beautiful phenomenon of a parhelion, or mock-sun. The real luminary was only ten degrees above the horizon, when, all at once, another sun appeared to plant itself within six degrees of the former: It consisted of numerous prismatic rings, delicately tinted on a ground of dazzling whiteness. At half past six o'clock, after a voyage of an hour and a half, they safely alighted near Magny, about fifteen miles distant from Dijon.

His second Ascent.

With the same balloon, M. Guyton-Morveau made a second ascent, on the 12th of June, accompanied by the President de Virly. It was launched at seven o'clock in the morning, the barometer being then at 29.5 inches, the thermometer at 66°, and Saussure's hygrometer at $83\frac{1}{2}$°. It swelled very fast, however, owing to the effect of the sun's increasing heat; and the upper valve being at intervals opened, to give vent to excess of the gas, this escaped with a noise like the rushing of water. As the voyagers did not mount to any very great elevation, they enjoyed an agreeable temperature, and could easily, by observing the situation of the different villages scattered below them, trace out their tortuous route on the surface of the map. By nine o'clock, they had reached the height of 6030 feet, the barometer now standing at 24.7 inches, the thermometer at 70°, and the hygrometer at $65\frac{1}{2}$ Three quarters of an hour afterwards, they descended at the village of Etevaux, only twelve miles from Dijon, having described at least double this distance in the air. The heat had increased so much since the morning, that, notwithstanding the loss of elastic fluid. the balloon seemed yet nearly inflated, on touching the ground.

Remarkable Voyage of Testu.

An aërial voyage, most remarkable for its duration and its adventures, was performed on the 18th June, 1786, from Paris, by M. Testu, with a balloon 29 feet in diameter, constructed by himself of glazed tiffany, furnished with auxiliary wings, and filled, as usual, with hydrogen gas. It had been much injured by wind and rain during the night before its ascension; but having undergone a slight repair, it was finally launched, with its conductor, at four o'clock in the afternoon. The barometer then stood at 29.68

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inches, and the thermometer as high as 84°; though the day was cloudy and threatened rain. The balloon had at first been filled only five-sixths, but it gradually swelled as it became drier and warmer, and acquired its utmost distension at the height of 2800 feet. But to avoid the waste of gas, or the rupture of the silk, the navigator endeavoured to descend by the reaction of his wings. This force being insufficient, however, he threw out some ballast; and, at half past five o'clock, he softly alighted on a corn-field in the plain of Montmorency. Without leaving the car, he began to collect a few stones for ballast; when he was surrounded by the proprietor of the field and a troop of peasants, who insisted on being indemnified for the damage occasioned by his idle and curious visitors. Anxious now to disengage himself, he persuaded them, that, his wings being broken, he was wholly at their mercy; they seized the stay of the balloon, which floated at some height, and dragged their prisoner through the air in a sort of triumph towards the village. But M. Testu, finding that the loss of his wings, his cloak, and some other articles, had considerably lightened the machine, suddenly cut the cord, and took an abrupt leave of the clamorous and mortified peasants. He rose to the region of the clouds, where he observed small frozen particles floating in the atmosphere. He heard thunder rolling beneath his feet, and, as the coolness of the evening advanced, the buoyant force diminished, and, at three quarters after six o'clock, he approached the ground, near the Abbey of Royaumont. There he threw out some ballast, and in the space of twelve minutes rose to a height of 2400 feet, where the thermometer was only 66 degrees. He now heard the blast of a horn, and descried huntsmen below in full chace. Curious to witness the sport, he pulled the valve, and descended, at eight o'clock, between Etouen and Varville, when, rejecting his oars, he set himself to gather some ballast. While he was thus occupied, the hunters gallopped up to him. He mounted a third time, and passed through a dense body of clouds, in which thunder followed lightning in quick succession.

> With fresh alacrity and force renew'd,
> Springs upward, like a pyramid of fire,
> Into the wild expanse, and through the shock
> Of fighting elements, on all sides round
> Environ'd wins his way.

The thermometer fell to 21°, but afterwards regained its former point of 66°, when the balloon had reached the altitude of 3000 feet. In this region, the voyager sailed till half past nine o'clock, at which time he observed from his "watch-tower in the sky" the final setting of the sun. He was now quickly involved in darkness, and enveloped in the thickest mass of thunder-clouds. The lightnings flashed on all sides, and the loud claps were incessant. The thermometer, seen by the help of a phosphoric light which he struck, pointed at 21°, and snow and sleet fell copiously around him. In this most tremendous situation the intrepid adventurer remained the space of three hours, the time during which the storm lasted. The balloon was affected by a sort of undulating motion upwards and downwards, owing, he thought, to the electrical action of the clouds. The lightning appeared excessively vivid, but the thunder was sharp and loud, preceded by a sort of crackling noise. A calm at last succeeding, he had the pleasure to see the stars, and embraced this opportunity to take some necessary refreshment. At half past two o'clock, the day broke in; but his ballast being nearly gone, and the balloon again dry and much elevated, he resolved to descend to the earth, and ascertain to what point he had been carried. At a quarter before four o'clock, having already seen the sun rise, he safely alighted near the village of Campremi, about 63 miles from Paris.

Balloons in England.

At this period, ascents with balloons had been multiplied, not only through France, but all over Europe. They were very seldom, however, directed to any other object than amusement, and had soon degenerated into mere exhibitions for gain. The first balloon seen in England, was constructed by an ingenious Italian, the Count Zambeccari. It consisted of oiled silk, in a globular shape, about ten feet in diameter, and weighed only eleven pounds. It was entirely gilt, which not only gave it a beautiful appearance, but rendered it less permeable to the gas. On the 25th of November 1783, it was filled about three-fourths, and launched at one o'clock from the Artillery Ground, and in the presence of a vast concourse of spectators. At half-past three in the afternoon, it was taken up at Petworth, in Sussex, about the distance of forty-eight miles. It was not till the following year, on the 21st of September, that a countryman of his, named Lunardi, first mounted in a balloon at London. He afterwards repeated the experiment in different parts of England, and during the following year in Scotland. This active person took an expeditious but careless method to fill his balloon with gas. He had two large casks sunk into the ground, for their better security, in which he deposited 2000 pounds of the borings of cannon, divided by layers of straw, to present a larger surface. An equal weight of sulphuric acid, or common oil of vitriol, diluted with six times as much water, was poured upon the iron, and the hydrogen gas now formed, without being cooled or washed, was immediately introduced into the balloon. To Lunardi succeeded Blanchard, who possessed just as little science, but had greater pretensions, and some share of dexterity and skill. This adventurer is said to have performed not fewer than thirty-six voyages through the air, and to have acquired a large sum of money by those bold and attractive exhibitions. His most remarkable journey was across the British Channel, in company with Dr Jeffries, an American gentleman. On the 7th of January 1785, in a clear frosty day, the balloon was launched from the cliff of Dover, and, after a perilous course of two hours and three quarters, it alighted in safety on the edge of the forest of Guiennes, not far beyond Calais. By the magistrates of this town were the two aërial travellers treated with the utmost kindness and hospitality; and their wondrous arrival was welcomed as a happy omen, alas! how fallacious, of the lasting harmony to subsist between rival nations, now cemented by the conclusion of the famous Commercial Treaty.

Zambeccari. Lunardi. Blanchard.

The original smoke balloon of Montgolfier ap-

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pears to have gradually fallen into disrepute, and the more elegant and expensive, but far more powerful construction, which employs varnished silk to contain hydrogen gas, came to be generally preferred. With due precaution and management, the sailing through the atmosphere is perhaps scarcely more dangerous now than the navigating of the ocean. Of some hundred ascents made at different times with balloons, not above two cases are recorded to have had a fatal termination. The first was rendered memorable by the shocking death of the accomplished and interesting Rozier, who perished a martyr to his ardent zeal for the promotion of science. Being anxious to return the visit which Blanchard and Jeffries had paid to the French coast, by crossing the channel again and descending in England; he transported his balloon, which was of a globular shape, and forty feet in diameter, to Boulogne; and after various delays, occasioned chiefly by adverse winds, he mounted on the 15th June 1785, with his companion, M. Romain. From some vague idea of being better able to regulate the ascent of the balloon, he had most incautiously suspended below it a small smoke one of ten feet diameter; a combination, to which may be imputed the disastrous issue. Scarcely a quarter of an hour had elapsed, when the whole apparatus, at the height of above three thousand feet, was observed to be on fire; and its scattered fragments, with the unfortunate voyagers, were precipitated to the ground. They fell near the sea-shore, about four miles from Boulogne, and were instantly killed by the tremendous shock, their bodies being found most dreadfully mangled.—The next fatal accident with balloons, happened in Italy, several years later, when a Venetian nobleman and his lady, after having performed successfully various ascents, fell from a vast height, and perished on the spot.

Shocking Fate of Rozier and Romain.

The Parachute.

Balloonists have, no doubt, been often exposed, in their aërial excursions, to the most imminent hazard of their lives. The chief danger consists in the difficulty of preventing sometimes a rapid and premature descent. To guard, in some degree, against the risks arising from the occurrence of such accidents, the *Parachute* was afterwards introduced; being intended to enable the voyager, in cases of alarm, to desert his balloon in mid-air, and drop, without sustaining injury, to the ground. The French language, though not very copious, has yet supplied this convenient term, signifying *a guard for falling*, as it has likewise furnished the words of analogous composition, *parapluie*, *paravent*, and *parasol*, to denote *an umbrella*, *a shade for the sun*, and *a door-screen*. The *parachute* very much resembles the ordinary umbrella, but has a far greater extent. The umbrella itself, requiring such strength to bear it up against a moderate wind, might naturally have suggested the application of the same principle to break the force of a fall. Nothing was required but to present a surface having dimension sufficient to experience from the air a resistance equal to the weight of descent, in moving through the fluid with a velocity not exceeding that of the shock which a person can sustain without any danger. Accordingly, in the East, where the umbrella, or rather the parasol, has been, from the remotest ages, in familiar use, this implement appears to be occasionally employed by vaulters, for enabling them to jump safely from great heights. Father Louberc, in his curious account of Siam, relates that a person famous, in that remote country, for his dexterity, was accustomed to divert exceedingly the king and the royal court, by the prodigious leaps which he took, having two umbrellas, with long slender handles, fastened to his girdle. He generally alighted on the ground, but was sometimes carried by the wind against trees or houses, and not unfrequently into the river.—Not many years since, the umbrella was at least, on one occasion, employed in Europe, with similar views, but directed to a very different purpose. In the early part of the campaign of 1793, the French general, Beurnonville, having been sent by the National Convention, with four more commissioners, to treat with the Prince of Saxe-Cobourg, was, contrary to the faith or courtesy heretofore preserved in the fiercest wars that have raged among civilized nations, detained a prisoner with his companions, and sent to the fortress of Olmutz, where he suffered a rigorous confinement. In this cruel situation, he made a desperate attempt to regain his liberty. Having provided himself with an umbrella, he jumped from a window at the height of forty feet; but being a very large heavy man, this screen proved insufficient to check his precipitate descent; he struck against the opposite wall, fell into the ditch, and broke his leg, and was carried in this condition back again to his dungeon.

First used.

Blanchard was the first who constructed parachutes, and annexed them to balloons, for the object of affecting his escape in case of accident. During the excursion which he undertook from Lisle, about the end of August 1785, when this adventurous aëronaut traversed, without halting, a distance not less than 300 miles, he let down a dog from a vast height in the basket of a *parachute*, and the poor animal, falling gently through the air, reached the ground unhurt. Since that period, the practice and management of the *parachute* have been carried much farther by other aërial travellers, and particularly by M. Garnerin, who has dared repeatedly to descend from the region of the clouds with that very slender machine. This ingenious and spirited Frenchman visited London during the short peace of 1802, and made two fine ascents with his balloon, in the second of which he threw himself from an amazing elevation with a parachute. This consisted of thirty-two gores of white canvass formed into a hemispherical case of twenty-three feet diameter, at the top of which was a truck or round piece of wood ten inches broad, and having a hole in its centre, admitting short pieces of tape to fasten it to the several gores of the canvas. About four feet and a half below the top, a wooden hoop of eight feet in diameter was attached by a string from each seam; so that when the balloon rose, the parachute hung like a curtain from this hoop. Below it was suspended a cylindrical basket covered with canvas, about four feet high, and two and a quarter wide. In this basket, the aëronaut, dressed in a close jacket and a pair of trowsers, placed himself, and rose majestically from an inclosure near North Audley Street at six o'clock in the evening of the 2d of September. After ho-

Garnerin's Descent.

vering seven or eight minutes in the upper region of the atmosphere, he meditated a descent in his parachute. Well might he be supposed to linger there in dread suspense, and to

> ———————————— look a while
> Pondering his voyage; for no narrow frith
> He had to cross.————
> He views the breadth, and, without longer pause,
> Downright into the world's first region throws
> His flight precipitant, and winds with ease,
> Through the pure marble air, his oblique way.

He cut the cord by which his parachute was attached to the net of the balloon; it instantly expanded, and for some seconds it descended with an accelerating velocity, till it became tossed extremely, and took such wide oscillations, that the basket or car was at times thrown almost into an horizontal position. Borne along likewise by the influence of the wind, the parachute passed over Mary-le-bonne and Somers-Town, and almost grazed the houses of St Pancras. At last it fortunately struck the ground in a neighbouring field, but so violent was the shock as to throw poor Garnerin on his face, by which accident he received some cuts, and bled considerably. He seemed to be much agitated, and trembled exceedingly at the moment he was released from the car. One of the stays of the parachute had chanced to give way, which untoward circumstance deranged the apparatus, disturbed its proper balance, and threatened the adventurer, during the whole of his descent, with immediate destruction. The feeling of such extreme peril was too much for human nature to bear.

Theory of the Parachute.

From the principles before explained, we may easily determine the descent of a parachute. When, with its attached load, it is abandoned in the air, it must, from the continued action of gravity, proceed at first with an accelerated motion, till its increasing velocity comes to oppose a resistance equal to the force of attraction, or to the combined weight of the whole apparatus. After this counterpoise has taken place, there existing no longer any cause of acceleration, the parachute should descend uniformly with its acquired rapidity. This perfect equilibrium will not, however, be attained at once. The accumulation of swiftness produced by the unceasing operation of gravity, is not immediately restrained by the corresponding increased resistance of the atmosphere. The motion of a parachute must hence, for some short time, be subject to a sort of interior oscillation, alternately accelerating and retarding. It first shoots beyond the terminal velocity, and then, suffering greater resistance, it relaxes, and contracts within the just limits. This unequal and undulating progress which a parachute exhibits, subsequent to the commencement of its fall, is calculated to excite disproportionate alarms of insecurity and danger.

Rate of its Descent.

The terminal velocity of a parachute, or the uniform velocity to which its motion tends, would, according to theory, be equal, if its surface were flat, to the velocity that a heavy body must acquire in falling through the altitude of a column of air incumbent on that surface, and having, under the usual circumstances, the same weight as the whole apparatus. But we have already seen, that a cylinder of air, one foot in diameter and height, weighs only, in ordinary cases, the seventeenth part of a pound *avoirdupois*. Wherefore, if the square of the diameter of a parachute be divided by 17, the quotient will give the number of pounds equivalent to the weight of an atmospheric column of one foot; and the weight of the apparatus being again divided by this quotient, the result will express the entire altitude of an equiponderant column. Of this altitude, the square root multiplied by 8, will denote the final velocity, or that with which the parachute must strike the ground. Suppose, for example, that the diameter of the parachute were 25 feet: Then $25 \times 25 = 625$, and this, divided by 17, gives $36\frac{13}{17}$ Consequently, if the parachute with its load weighed only $36\frac{13}{17}$ pounds, the shock received at the surface of the earth would be precisely the same as that which is felt in dropping from an elevation of one foot. Had the weight of the apparatus, therefore, been four times greater, or $147\frac{1}{17}$ pounds, the shock sustained would be the same as that from a fall of four feet; which is near the limit, perhaps, of what a person can bear without suffering injury from the violence of concussion. The velocity of descent, on this latter supposition, would be $8\sqrt{4}$, or sixteen feet each second.

Correct Formula.

But the actual resistance of the air is rather greater than what theory would give, and it is besides augmented by the concavity of the opposing surface, which occasions an accumulation of the fluid. Let $a$ denote the diameter of a parachute, and $f$ the total weight of the apparatus abandoned to its gravity in the atmosphere; if we take Dr Hutton's valuable experiments for the basis of the calculation, the terminal velocity of descent may be expressed in round numbers, by $\frac{26}{a}\sqrt{f}$, in feet each second, and consequently the length of fall which would occasion the same shock, is $\left(\frac{13}{4a}\right)^2 . f$, or very nearly $\frac{10\frac{1}{2}}{a^2} \cdot f$. Thus, if the parachute had thirty feet in diameter, and weighed, together with its appended load, 225 pounds; then $\frac{26}{30}\sqrt{225} = \frac{26}{30} \times 15 = \frac{13}{15} \times 15 = 13$ feet, or the velocity with which it would strike the ground; and $\left(\frac{13}{120}\right)^2 225 = 2\frac{3}{8}$ feet, being the height from which a person dropping freely would receive the same shock.

Celerity in the higher Regions.

Since the resistance which air opposes to the passage of a body is diminished by rarefaction, it is evident, that the parachute disengaged from a balloon, in the more elevated regions of the atmosphere, will at first acquire a greater velocity than it can afterwards maintain as it approaches the ground. Resuming the notation employed before, the ratio of the density of the air at the surface, and at any given height being expressed by $n : m$; then the velocity of counterpoise at that elevation, would be $\frac{26}{a}\sqrt{\frac{m}{n} \cdot f}$, or it would be equal to what is accumulated in falling freely a height of $\frac{10\frac{1}{2}}{a^2} \cdot \frac{m}{n} \cdot f$ feet. It is the final velocity, however, that must be chiefly

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considered in parachutes, being what determines the shock sustained in alighting. The violence of the rushing through the air will seldom be attended with any serious inconvenience. If we suppose the mean velocity with which a parachute descends to be twelve feet each second, this will correspond to the rate of a mile in $7\frac{1}{2}$ minutes; not more than that of a very gentle trot. We are not told from what height Garnerin dropped: but if he took four minutes in his descent, it was probably about half a mile.

The practice of aëronautics has not realized those expectations of benefit to mankind which sanguine projectors were at first disposed to entertain. It was soon found, that a balloon, launched into the atmosphere, is abandoned, without guidance or command, to the mercy of the winds. To undertake to direct or impel the floating machine by any exertion of human strength, was evidently a chimerical attempt. All the influence which the aëronaut really possesses, consists in a very limited power of raising or depressing it, according to circumstances. He cannot hope to shape his course, unless by skilfully adapting his elevation to catch the prevailing currents.

Balloons used in War.

Almost the only purpose to which balloons have hitherto been applied with success, had for its object that of military *reconnoisance*. In the early part of the French revolutionary war, when ingenuity and science were so eagerly called into active service, a balloon, prepared under the direction of the *Aërostatic Institute* in the Polytechnic School, and entrusted to the command of two or three experienced officers, was distributed to each of the republican armies. The decisive victory which General Jourdan gained, in June 1794, over the Austrian forces in the plains of Fleurus, has been ascribed principally to the accurate information of the enemy's movements before and during the battle, communicated by telegraphical signals from a balloon which was sent up to a moderate height in the air. The aëronauts, at the head of whom was the celebrated Guyton-Morveau, mounted twice in the course of that day, and continued, about four hours each time, hovering in the rear of the army at an altitude of 1300 feet. In the second ascent, the enterprize being discovered by the enemy, a battery was opened against them; but they soon gained an elevation above the reach of the cannon. Another balloon, constructed by the same skilful artist, M. Conté, was attached to the army sent on the memorable expedition to Egypt. What service it rendered the daring invader in the wide plains and sandy deserts of Africa, we are not informed; but, after the capitulation of Cairo, it was brought back, with the remains of the army, to France, and employed in the sequel, as we shall find, more innocently in philosophical research. These balloons, being calculated for duration, were of a more solid and perfect construction than usual. Originally they were filled with hydrogen gas, obtained from the decomposition of water on a large scale. For this purpose, six iron cylinders had been fixed by masonry in a simple kind of furnace, each of their ends projecting, and covered with an iron lid. Two sets of metal tubes were also inserted, the one for conveying hot water, and the other for carrying off the gas which was formed. The cylinders being charged with iron-turnings, and brought to a red-heat, the humidity was instantly converted into steam and decomposed, the oxygen uniting with the iron, while the hydrogen gas was discharged, and made to deposite any carbonic gas that might adhere to it, by passing through a reservoir filled with caustic lye before it entered the balloon. By this method, there was procured, at a very moderate expense, and in the space of about four hours, a quantity of hydrogen gas sufficient to inflate a balloon of thirty feet in diameter.

Method of filling them.

The ascents with balloons should appear to furnish the readiest means of ascertaining important facts in meteorology and atmospheric electricity, departments of science which are still unfortunately in their infancy. Some aëronauts have asserted that the magnetic needle ceased to traverse at very great elevations in the atmosphere; a statement which received some countenance from the observations made by Saussure on the lofty summit of the Col du Geant, where that celebrated naturalist thought he had found the magnetic virtue to be diminished one-fifth part. It has been pretended by others, that the air of the higher regions is not of the same composition as at the surface of the earth, and is, independent altogether of its rarity, less fitted for the purpose of respiration. To determine these, and other relative points, was, therefore, an object interesting to the progress of physical science. A few years since, two young and ardent French philosophers, MM. Biot and Gay-Lussac, proposed to undertake an aërial ascent, in order to examine the magnetic force at great elevations, and to explore the constitution of the higher atmosphere and its electrical properties. For such a philosophical enterprize, they were eminently qualified, having been educated together at the Polytechnic School, and both of them deeply versed in mathematics; the former indulging in a wide range of study, and the latter concentrating his efforts more on chemistry, and its application to the arts. Their offer to government was seconded by Berthollet and Laplace, and the celebrated chemist Chaptal, then minister of the interior, gave it his patronage and warm support. The balloon which had once visited Egypt was delivered to the custody of Biot and Gay-Lussac, and the same artist who constructed it was, at the public expense, ordered to refit and prepare it under their direction. Besides the usual provision of barometers, thermometers, hygrometers, and electrometers; they had two compasses, and a dipping-needle, with another fine needle, carefully magnetized, and suspended by a very delicate silk thread, for ascertaining by its vibrations the force of magnetic attraction. To examine the electricity of the different strata of the atmosphere, they carried several metallic wires, from sixty to three hundred feet in length, and a small electrophorus feebly charged. For galvanic experiments, they had procured a few discs of zinc and copper, with some frogs; to which they added insects and birds. It was also intended to bring down a portion of air from the higher re-

Scientific Ascent of Biot and Gay-Lussac.

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gions, to be subjected to a chemical analysis; and for this purpose a flask, carefully exhausted, and fitted with a stop-cock, had been prepared.

The balloon was placed in the garden of the *Conservatoire des Arts*, or Repository of Models, formerly the Convent of St Martin, and no pains were spared by Conté in providing whatever might contribute to the greater safety and convenience of the voyagers. Every thing being now ready for their ascent, these adventurous philosophers, in the presence of a few friends, embarked in the car at ten o'clock in the morning of the 23d of August 1804. The barometer was then at 30.13 inches, the thermometer at 61°.7 on Fahrenheit's scale, and Saussure's hygrometer pointed at 80°.8, or very near the limit of absolute humidity. They rose with a slow and imposing motion; their feelings were at first absorbed in the novelty and magnificence of the spectacle which opened before them; and their ears were saluted with the buzz of distant gratulations, sent up from the admiring spectators. In a few minutes, they entered the region of the clouds, which seemed like a thin fog, and gave them a slight sensation of humidity. The balloon had become quite inflated, and they were obliged to let part of the gas escape, by opening the upper valve; at the same time, they threw out some ballast, to gain a greater elevation. They now shot through the range of clouds, and reached an altitude of about 6,500 English feet. These clouds, viewed from above, had the ordinary whitish appearance; they all occupied the same height, only their upper surface seemed marked with gentle swells and undulations, exactly resembling the aspect of a wide plain covered with snow.

Their experimental Operations.

MM. Biot and Gay-Lussac now began their experimental operations. The magnetic needle was attracted, as usual, by iron; but they found it impossible at this time to determine with accuracy its rate of oscillation, owing to a slow rotatory motion with which the balloon was affected. In the meanwhile, therefore, they made other observations. A Voltaic pile, consisting of twenty pairs of plates, exhibited all its ordinary effects,—gave the pungent taste, excited the nervous commotion, and occasioned the decomposition of water. By rejecting some more ballast, they had attained the altitude of 8,940 feet, but afterwards settled to that of 8,600 feet. At this great elevation, the animals which they carried with them appeared to suffer from the rarity of the air. They let off a violet bee, which flew away very swiftly, making a humming noise. The thermometer had fallen to 56°.4 by Fahrenheit, yet they felt no cold, and were, on the contrary, scorched by the sun's rays, and obliged to lay aside their gloves. Both of them had their pulses much accelerated; that of Biot, which generally beats seventy-nine times in a minute, was raised to one hundred and eleven, while the pulse of his friend Gay-Lussac, a man of a less robust frame, was heightened from sixty to eighty beats in the minute. Notwithstanding their quickened pulsation, however, they experienced no sort of uneasiness, nor any difficulty in breathing.

Magnetical Observations.

What perplexed them the most, was the difficulty of observing the oscillations of a delicately suspended magnetic needle. But they soon remarked, on looking attentively down upon the surface of the conglomerated clouds, that the balloon slowly revolved, first in one direction, and then returned the contrary way. Between these opposite motions there intervened short pauses of rest, which it was necessary for them to seize. Watching, therefore, the moments of quiescence, they set the needle to vibrate, but were unable to count more than five, or very rarely, ten oscillations. A number of trials made between the altitudes of 9,500 and 13,000 feet, gave 7″ for the mean length of an oscillation, while, at the surface of the earth it required $7\frac{1}{20}''$ to perform each oscillation. A difference so very minute as the hundred and fortieth part could be imputed only to the imperfection of the experiment, and it was hence fairly concluded, that the force of magnetic attraction had in no degree diminished at the greatest elevation which they could reach. The direction of this force too, seemed, from concurring circumstances, to have continued the same; though they could not depend on observations made in their vacillating car with so delicate an instrument as the dipping-needle.

Birds liberated at vast Heights.

At the altitude of 11,000 feet, they liberated a green-linnet, which flew away directly; but, soon feeling itself abandoned in the midst of an unknown ocean, it returned and settled on the stays of the balloon. Then mustering fresh courage, it took a second flight, and dashed downwards to the earth, describing a tortuous, yet almost perpendicular track. A pigeon which they let off under similar circumstances, afforded a more curious spectacle: Placed on the edge of the car, it rested a while, measuring, as it were, the breadth of that unexplored sea which it designed to traverse; now launching into the abyss, it fluttered irregularly, and seemed at first to try its wings in the thin element; till, after a few strokes, it gained more confidence, and, whirling in large circles or spirals, like the birds of prey, it precipitated itself towards the mass of extended clouds, where it was lost from sight.

It was difficult, in those lofty and rather humid regions, to make electrical observations; and the attention of the scientific navigators was besides occupied chiefly by their magnetical experiments. However, they let down from the car an insulated metallic wire of about 250 feet in length, and ascertained, by means of the electrophorus, that the upper end indicated resinous or negative electricity. This experiment was several times repeated; and it seemed to corroborate fully the previous observations of Saussure and Volta, relative to the increase of electricity met with in ascending the atmosphere.

Diminution of Temperature.

The diminution of temperature in the higher regions was found to be less than what is generally experienced at the same altitude on mountains. Thus, at the elevation of 12,800 feet, the thermometer was at 51° by Fahrenheit, while it stood as low as 63½° at the Observatory; being only a decrement of one degree for each 1000 feet of ascent. This fact corresponds with the observations made by former aëronauts, and must have been produced, we conceive, by the operation of two distinct causes. First, the rays from the sun not being enfeebled by passing through the denser portion of the atmosphere, would

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act with greater energy on the balloon and its car, and consequently affect the thermometer placed in their vicinity. Next, the warm current of air, which, during the day, rises constantly from the heated surface of the ground, must augment the temperature of any body which is exposed to its influence. During the night, on the contrary, the upper strata of the atmosphere would be found colder, we presume, than the general standard, owing to the copious descent of chill portions of air from the highest regions.

Hygrometric Observations.

The hygrometer, or rather hygroscope, of Saussure, advanced regularly towards dryness, in proportion to the altitude which they attained. At the elevation of 13,000 feet, it had changed from 80°.8 to 30°. But still the conclusion, that the air of the higher strata is dryer than that of the lower, we are inclined to consider as fallacious. In fact, the indications of the hygroscope depend on the relative attraction for humidity possessed, by the substance employed, and the medium in which it is immersed. But air has its disposition to retain moisture always augmented by rarefaction, and consequently such alteration alone must materially affect the hygroscope. The only accurate instrument for ascertaining the condition of air with respect to dryness, is founded on a property of evaporation. But we shall afterwards have occasion to discuss this subject at due length.

Their Descent.

The ballast now being almost quite expended, it was resolved to descend. The aëronauts therefore pulled the upper valve, and allowed part of the hydrogen gas to escape. They dropped gradually, and when they came to the height of 4,000 feet, they met the stratum of clouds, extending horizontally, but with a surface heaved into gentle swells. When they reached the ground, no people were near them to stop the balloon, which dragged the car to some distance along the fields. From this awkward and even dangerous situation, they could not extricate themselves without discharging the whole of their gas; and therefore, giving up the plan of sending M. Gay-Lussac alone to explore the highest regions. It has been reported that his companion M. Biot, though a man of activity and apparently not deficient in personal courage, was so much overpowered by the alarms of their descent, as to lose for the time the entire possession of himself. The place where they alighted, at half past one o'clock, after three hours and a half spent in the midst of the atmosphere, was near the village of Meriville, in the department of the Loiret, and about fifty miles from Paris.

It was the desire of several philosophers at Paris that M. Gay-Lussac should mount a second time, and repeat the different observations at the greatest elevation he could attain. Experience had instructed him to reduce his apparatus, and to adapt it better to the actual circumstances. As he could only count the vibrations of the magnetic needle during the very short intervals which occurred between the contrary rotations of the balloon, he preferred one of not more than six inches in length, which therefore oscillated quicker. The dipping needle was magnetized and adjusted by the ingenious M. Coulomb. To protect the thermometer from the direct action of the sun, it was inclosed within two concentric cylinders of pasteboard covered with gilt paper. The hygrometer, constructed on Richer's mode, with four hairs, were sheltered nearly in the same way. The two glass flasks intended to bring down air from the highest regions of the atmosphere, had been exhausted till the mercurial gage stood at the 25th part of an inch, and their stop-cocks were so perfectly fitted, that, after the lapse of eight days, they still preserved the vacuum. These articles, with two barometers, were the principal instruments which M. Gay-Lussac took with him. The skill and intelligence of the artist had been exerted in farther precautions for the safety of the balloon.

Gay-Lussac ascends again alone.

At forty minutes after nine o'clock on the morning of the 15th of September, the scientific voyager ascended as before, from the garden of the Repository of Models. The barometer then stood at 30.66 English inches, the thermometer at 82° by Fahrenheit, and the hygrometer at 57½°. The sky was unclouded, but misty. Scarcely had the observer reached the height of 3000 feet, than he observed spread below him, over the whole extent of the atmosphere, a thin vapour, which rendered the distant objects very indistinct. Having gained an altitude of 9,950 feet, he set his needle to vibrate, and found it to perform twenty oscillations in 83″, though it had taken 84″.33 to make the same number at the surface of the earth. At the height of 12,680 feet, he discovered the variation of the compass to be precisely the same as below; but with all the pains he could take, he was unable to determine with sufficient certainty the dip of the needle. M. Gay-Lussac continued to prosecute his other experiments with the same diligence, and with greater success. At the altitude of 14,480 feet, he found that a key, held in the magnetic direction, repelled with its lower end, and attracted with its upper end, the north pole of the needle of a small compass. This observation was repeated, and with equal success, at the vast height of 20,150 feet; a clear proof that the magnetism of the earth exerts its influence at remote distances. He made not fewer than fifteen trials at different altitudes, with the oscillations of his finely suspended needle. It was generally allowed to vibrate twenty or thirty times. The mean result gives 4″.22 for each oscillation, while it was 4″.216 at the surface of the earth; an apparent difference so extremely small, as to be fairly neglected.

His Observations in Magnetism.

Successive Decrements of Temperature.

During the whole of his gradual ascent, he noticed, at short intervals, the state of the barometer, the thermometer, and the hygrometer. Of these observations, amounting in all to twenty-one, he has given a tabular view. We regret, however, that he has neglected to mark the times at which they were made, since the results appear to have been very considerably modified by the progress of the day. It would likewise have been desirable, to have compared them with a register noted every half hour at the Observatory. From the surface of the earth to the height of 12,125 feet, the temperature of the atmosphere decreased regularly from 82° to 47°.3 by Fahrenheit's scale. But afterwards it increased again, and reached to 53°.6, at the altitude of 14,000 feet; evidently owing to the influence of the warm currents of air, which, as the day advanced, rose continually from the heated ground. From that

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point, the temperature diminished, with only slight deviations from a perfect regularity. At the height of 18,636 feet, the thermometer subsided to 32°.9, on the verge of congelation; but it sunk to 14°.9, at the enormous altitude of 22,912 feet above Paris, or 23,040 feet above the level of the sea, the utmost limit of the balloon's ascent.

Comparison of these Observations.

From these observations, no conclusive inference, we think, can be drawn respecting the mean gradation of cold which is maintained in the higher regions of the atmosphere; for, as we have already remarked, the several strata are, during the day, kept considerably above their permanent temperature, by the hot currents raised from the surface through the action of the sun's rays. If we adopt the formula given by Professor Leslie at the end of his Elements of Geometry, which was the result of some accurate and combined researches, the diminution of temperature corresponding to the first part of the ascent or 12,125 feet, ought to be forty degrees of Fahrenheit: It was actually 34°.7, and would no doubt have approached to 40°, if the progressive heating of the surface, during the interval of time, were taken into the account. In the next portion of the voyage, from the altitude of 14,000 to that of 18,636 feet, or the breadth of 4,636 feet, the decrement of temperature according to the formula should only have been $16\frac{1}{4}$°, instead of 20°.7 whch was really marked; a proof that the diurnal heat from below had not yet produced its full effect at such a great height. In the last portion of the balloon's ascent, from 18,636 feet to 22,912, a range of 3,276 feet, the decrease of heat ought to be $15\frac{1}{2}$°, and it was actually 18°; owing most probably to the same cause, or the feebler influence which warm currents of air from the surface exert at those vast elevations. Taking the entire range of the ascent, or 22,912 feet, the diminution of temperature according to the same formula, would be for the gradation of temperature in ascending the atmosphere 85°.4. The decrease actually observed was 67°.1, which might be raised to 80°, if we admit the very probable supposition, that the surface of the earth had become heated from 82° to 94°.9 during the interval between ten o'clock in the morning and near three in the afternoon, when the balloon floated at its greatest elevation.

After making the fair allowances, therefore, on account of the operation of deranging causes, the results obtained by M. Gay-Lussac, for the gradation of temperature in the atmosphere, appear, on the whole, to agree very nearly with those derived from the formula which theory, guided by delicate experiments, had before assigned. This gradation is evidently not uniform, as some philosophers have assumed; but proceeds with augmented rapidity in the more elevated regions. The same conclusion results from a careful inspection of the facts which have been stated by other observers.

Indications of the Hygrometer.

The hygrometers, during the ascent of the balloon, held a progress not quite so regular, but tending obviously towards dryness. At the height of 9,950 feet, they had changed from 57°.5 to 62°; from which point they continued afterwards to decline, till they came to mark 27°.5, at the altitude of 15,190 feet. From this inferior limit, the hygrometers advanced again, yet with some fluctuations, to 35°.1, which they indicated at the height of 18,460 feet. Above this altitude, the variation was slight, though rather inclining to humidity. There can exist no doubt, however, that, allowing for the influence of the prevailing cold, the higher strata of the atmosphere must be generally drier than the lower, or capable of retaining, at the same temperature, a larger share of moisture.

Prospect of the highest Atmosphere.

At the altitude of 21,460 feet, M. Gay-Lussac opened one of his exhausted flasks; and at that of 21,790 feet, the other. The air rushed into them, through the narrow aperture, with a whistling noise. He still rose a little higher, but, at eleven minutes past three o'clock, he had attained the utmost limit of his ascent, and was then 22,912 feet above Paris, or 23,040 feet, being more than four miles and a quarter above the level of the sea. The air was now more than twice as thin as ordinary, the barometer having sunk to 12.95 inches. From that stupendous altitude, sixteen hundred feet above the summit of the Andes, more elevated than the loftiest pinnacle of our globe, and far above the heights to which any mortal had ever soared, the aërial navigator might have indulged the feelings of triumphant enthusiasm. But the philosopher, in perfect security, was more intent on calmly pursuing his observations. During his former ascent, he saw the fleecy clouds spread out below him, while the canopy of heaven seemed of the deepest azure, more intense than Prussian blue. This time, however, he perceived no clouds gathered near the surface, but remarked a range of them stretching, at a very considerable height, over his head; the atmosphere, too, wanted transparency, and had a dull, misty appearance. The different aspect of the sky was probably owing to the direction of the wind, which blew from the north-north-west, in his first voyage, but in his second, from the south-east.

Feelings of Gay-Lussac.

While occupied with experiments at this enormous elevation, he began, though warmly clad, to suffer from excessive cold, and his hands, by continual exposure, grew benumbed. He felt likewise a difficulty in breathing, and his pulse and respiration were much quickened. His throat became so parched from inhaling the dry attenuated air, that he could hardly swallow a morsel of bread. But he experienced no other direct inconvenience from his situation. He had indeed been affected, through the whole of the day, with a slight head-ache, brought on by the preceding fatigues and want of sleep; but though it continued without abatement, it was not increased by his ascent.

His Descent.

The balloon was now completely distended, and not more than 33 pounds of ballast remained, it began to drop, and M. Gay-Lussac therefore only sought to regulate its descent. It subsided very gently, at the rate of about a mile in eight minutes, and after the lapse of thirty-four minutes, or at three quarters after three o'clock, the anchor touched the ground, and instantly secured the car. The voyager alighted with great ease near the hamlet of St Gourgon, about sixteen miles north-west from Rouen. The inhabitants flocked around him, offering him assistance, and eager to gratify their curiosity.

His Analysis of the

As soon as he reached Paris, he hastened to the laboratory of the Polytechnic School, with his flasks

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Air brought down.

containing air of the higher regions, and proceeded to analyse it, in the presence of Thenard and Gresset. Opened under water, the liquid rushed into them, and apparently half filled their capacity. The transported air was found by a very delicate analysis to contain exactly the same proportions as that collected near the surface of the earth, every 1000 parts holding 215 of oxygen. From concurring observations, therefore, we may conclude that the atmosphere is essentially the same in all situations.

Remarks on these last Ascents.

The ascents performed by MM. Biot and Gay-Lussac are memorable, for being the first ever undertaken solely for objects of science. It is impossible not to admire the intrepid coolness with which they conducted those experiments, operating, while they floated in the highest regions of the atmosphere, with the same composure and precision, as if they had been quietly seated in their cabinets at Paris. Their observations on the force of terrestrial magnetism, shew most satisfactorily its deep source and wide extension. The identity of the constitution of the atmosphere, to a vast altitude, was likewise ascertained. The facts noted by Gay-Lussac, relative to the state of the thermometer at different heights, appear generally to confirm the law which theory assigns for the gradation of temperature in the atmosphere. But many interesting points were left untouched by this philosopher. We are sorry that he had not carried with him the *cyanometer*, which enabled Saussure to determine the colour of the sky on the summits of the Swiss mountains. Still more we regret that he was not provided with an hygrometer and a photometer, of Leslie's construction. These delicate instruments could not have failed, in his hands, to furnish important data, for discovering the relative dryness and transparency of the different strata of air. It would have been extremely interesting, at such a tremendous height, to have measured with accuracy the feeble light reflected from the azure canopy of heaven, and the intense force of the sun's direct rays, and hence to have determined what portion of them is absorbed in their passage through the lower and denser atmosphere.

Various Projects with Balloons.

Balloons have at different times been thought capable of useful application. It has been even proposed to employ their power of ascension as a mechanical force. This might be rendered sufficient, it was believed, to raise water from mines, or to transport obelisks, and place them on great elevations. We can easily imagine situations where a balloon could be used with advantage; such as to raise, without any scaffolding, a cross or a vane to the top of a high spire. But the power would then be purchased at a very disproportionate expense. It would require $4\frac{1}{2}$ pounds of iron, or 6 of zinc, with equal quantities of sulphuric acid, to yield hydrogen gas sufficient to raise up the weight of one pound.

The proposal of employing balloons in the defence and attack of fortified places appears truly chimerical. They have rendered important service, however, in reconnoitring the face of a country, and communicating military signals; and it is rather surprising that a system, which promised such obvious benefits, has not been carried much farther.

Their Application proposed for the Improvement of Meteorology.

But to a skilful and judicious application of balloons, we may yet look for a most essential improvement of the infant science of meteorology. Confined to the surface of this globe, we have no direct intimation of what passes in the lofty regions of the atmosphere. All the changes of weather, which appear so capricious and perplexing, proceed, no doubt, from the combination of a very few simple causes. Were the philosopher to penetrate beyond the seat of the clouds, examine the circumstances of their formation, and mark the prevailing currents, he would probably remove in part the veil that conceals those mighty operations. It would be quite practicable, we conceive, to reach an elevation of seven miles, where the air would be four times more attenuated than ordinary. A silk balloon, of forty feet diameter, if properly constructed, might be sufficient for that enormous ascent, since its weight would only be 80 pounds, while its buoyant force, though not more than a quarter filled with hydrogen gas, would amount to $533\frac{1}{3}$, leaving $453\frac{1}{3}$ pounds, for the passenger and the ballast. The balloon could be safely charged, indeed, to the third part of its capacity, on account of the contraction which the gas would afterwards suffer from the intense cold of the upper regions, and this gives it an additional buoyancy of $177\frac{8}{9}$ pounds. The voyager would not, we presume, suffer any serious inconvenience from breathing the very thin air. The animal frame adapts itself with wonderful facility to external circumstances. Perhaps the quickened pulse and short respiration, which some travellers have experienced on the summits of lofty mountains, should be attributed chiefly to the suddenness of their transition, and the severity of the cold. The people of Quito live comfortably 9560 feet above the level of the sea; and the shepherds of the hamlet of Antisana, the highest inhabited spot in the known world, who breathe at an elevation of 13,500 feet, air that has only three-fifths of the usual density, are nowise deficient in health or vigour. But the intenseness of the cold is probably what the resolute observer would have most to dread, at the height of seven miles. This decrease of temperature, perhaps equal to 148 degrees, might extend below the point at which mercury freezes. Yet several circumstances tend to mitigate such extreme cold, and proper clothing might enable an experimenter, for a short time, to resist its effects.

Much could be done, however, without risk or material expense. Balloons from fifteen to thirty feet in diameter, and carrying register thermometers and barometers, might be capable of ascending alone to altitudes between eight and twelve miles. Dispatched from the centres of the great continents, they would not only determine the extreme gradation of cold, but indicate by their flight the direction of the regular and periodic winds which doubtless obtain in the highest regions of the atmosphere. But we will not enlarge. In some happier times, such experiments may be performed with the zealous concurrence of different governments;—when nations shall at last become satisfied with cultivating the arts of peace, instead of wasting their energies in sanguinary, destructive, and fruitless wars. (D.)

# AFRICA.

Africa.

IN the general article given under this head in the body of the work, the reader will find a pretty accurate digest of the information collected by modern travellers in regard to this obscure division of the globe; but as that article either does not touch upon, or but slightly alludes to various disputed questions, of considerable interest, connected with its ancient and modern geography, it hence becomes necessary that we should here make some remarks upon the points in question, as well as upon the additional information which recent enterprize and inquiries have supplied. *

Knowledge of the Ancients regarding Africa.

I. The extent of the knowledge of this continent possessed by the ancients, forms one of the subjects of inquiry to which we allude, and upon which much learning and ingenuity have been employed.

Did they circumnavigate this Continent?

1. The first point to be considered under this head is, whether Africa was ever circumnavigated in ancient times? Herodotus states, that Necho, king of Egypt, fitted out an expedition under the direction of certain Phœnician navigators, for the purpose of circumnavigating it; and that these navigators asserted that they had succeeded in this adventurous undertaking. By some of the ancient writers, the account which Herodotus gives of this voyage was held altogether fabulous. Among the moderns, Huet (*Commerce et Navigation des Anciens*, 34, 275.), the Abbé Paris (*Academie des Sciences*, VII. 79.), Montesquieu (*Esprit des Lois*, b. xxi. ch. 10.), and some others, have contended that it was really performed; while Vossius (in his Notes to *Pomponius Mela*), and D'Anville have intimated a strong degree of scepticism. But the most elaborate discussion of the question has taken place between Major Rennell on the one side, and Dr Vincent and M. Gosselin on the other. The opinion of the two latter is also moderately espoused by Gibbon, in an essay just published in the fifth volume of his posthumous works.

Major Rennell (*Geog. Herodot.* 672-93) observes, that, though the ancient mode of sailing, confined to a very small distance from the coast, presented difficulties and obstructions unknown to modern navigation, it yet afforded resources for overcoming these difficulties, wholly foreign to the modern practice of the art. Navigators were thus enabled to discover all the creeks and harbours which any coast presented, and which escape vessels that steer at a distance from the shore. The construction of their ships, with very flat bottoms and low masts, enabled them to keep much nearer to the land, than modern vessels of the same magnitude. They could even, when the exigency required, be drawn up along the beach; and instances are quoted, in which large fleets were thus placed in a state of security. And as to the period of three years, specified as having been spent in the voyage,—this may be sufficiently accounted for by the slow rate of ancient sailing—by the difficulties of an unknown coast—and by the variety of opposing tides and currents.

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Dr Vincent (*Periplus of the Erythrean Sea*, I. 166—80), and M. Gosselin (*Geographie des Anciens* I. 199—242), on the other hand maintain, that such an expedition exceeds all the means and resources of ancient navigation. The Portuguese, who certainly equalled the Phœnicians both in skill and enterprize, accomplished it only step by step, each navigator building upon the experience of his predecessor; and nearly fifty years elapsed, till the whole was completed. Is it probable then, that a fleet, fitted out in a very imperfect state of the art, should at once, without previous information or experience, have traversed such an unknown extent of ocean, and doubled such a succession of stormy capes? The notice of the voyage is found only in Herodotus, and in a few writers who have copied from him; while others, among whom are Polybius and Ptolemy, whose general accuracy, and extensive knowledge cannot admit of question, positively assert, that Africa never had been circumnavigated.

Progress of the Ancients along the Western Coast of Africa.

2. Whatever opinion we may form as to the result of this voyage, it is certain that any geographical discoveries which were made in the course of it, entirely perished. All that the ancients knew with precision respecting the coasts of Africa beyond the Mediterranean and the Arabian Gulf, was due to subsequent navigators. The limit to which discovery extended on these coasts, has afforded much room for controversy among modern geographers. In particular, the question as to the extent of ancient navigation along the *western* coast, has given rise to a succession of learned and elaborate discussions. The document chiefly referred to in this controversy, is the *Periplus* of Hanno, which contains the journal of a voyage to the western coast, undertaken about thirty or forty years after the period of Necho's expedition. The objections stated by Dodwell, in the Oxford edition of the *Minor Greek Geographers*, against the authenticity of this celebrated document, seem to be now completely set aside; and it is justly esteemed as one of the most curious and valuable remains of ancient times. But widely differing opinions are maintained, both as to the extent of the coast sailed over by Hanno, and as to the objects to which his descriptions refer. Upon these points, Bougainville, Rennell, and Gosselin, have each advanced a different system; and in order to exhibit a view of these systems without confusion or repetition, we shall throw them into the form of a table. The first column will exhibit the description of the successive lines of coast, and their most remarkable features, as given by Hanno, who commences his narrative from the Straits of Gibraltar, then called the *Pillars of Hercules*. The others will shew the correspondent modern positions, as variously assigned by these three distinguished geographers.

* The reader will be assisted in the perusal of this article by occasionally referring to the accompanying map of Northern and Central Africa.

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| Description of Objects on the Coast, as given by *Hanno*. | Modern Positions, according to *Bougainville.* | *Rennell.* | *Gosselin.* |
|---|---|---|---|
| *Thymaterium*, overlooking a vast plain (two days sail) | Cape Cantin | Near Mamora | Cape Mollabat |
| Promontory of *Soloeis*, covered with trees | Cape Bojador | Cape Cantin | Cape Spartel |
| A days sail; five cities founded; then arrive at the great river *Lixus*, flowing from Lybia | Rio d'Ouro | Difficult to place | R. Lucos |
| After sailing two days west and one day east, arrive at the island of *Cerne* | Arguin | Arguin | Fedala |
| A large river called Chretes | R. St John | R. St John | R. Rebela |
| A bay or lake, with several islands larger than Cerne | Islands near its mouth | Islands near its mouth | Lake of the Negroes |
| A large river, full of crocodiles and hippopotami | The Senegal | The Senegal | R. Subu, or Saboe |
| Return to Cerne; twelve days sail along the coast of the Ethiopians; then a *Cape*, formed by mountains covered with odoriferous trees, doubled in two days | Cape St Anne near Sierra Leone | Cape Verd | Cape Geer |
| Five days sail along an immense gulf | To Cape Palmas | To C. Roxo (embonchure of the Gambia) | Gulf of Santa Cruz |
| A gulf called the *Western Horn;* large island with a salt water lake. Fires, with music, and loud cries during the night. Three days sail | To Cape Three Points | Gulf of Bissago | To Cape Nun |
| Large flaming mountain called the *Chariot of the Gods* | An extinguished volcano | Sagres | Fabulous |
| New Gulf called the *Southern Horn*, at which the voyage terminated. Another island and lake. *Gorillæ*, (oran outangs). | Gulf of Benin | Sherbro Sound | To river of Nun |

We may observe, that there is no precise register of the time spent in sailing from the Straits to Cerne. But another and later *Periplus*, bearing the name of Scylax, (*Geog. Græci Minores*), supplies this deficiency, by stating that distance at twelve days sail. From Cerne to the Southern Horn, twenty-six days are counted by Hanno. The whole number thus appears to be thirty-eight.

Bougainville.

Bougainville (*Academie des Sciences*, X. 45.) contends, that the space which he has supposed to be passed over in the above period of time, though considerable, does not exceed what might reasonably be expected from the most skilful navigators of antiquity. He instances the squadron sent, in 1641, to establish the fort of Elmina, which sailed from Lisbon to Arguin in twelve days, and thence to Cape Three Points in twenty-six; this, by a singular coincidence, being the precise period of time employed by Hanno. It is impossible, he continues, till we arrive at the Senegal, to find any great river which abounds in the wild amphibia mentioned in the journal. In that part only of the coast, have travellers observed those vegetable conflagrations, which might occasion the appearance of a flaming mountain. There only are found the oran outangs, undoubtedly pointed at by the name of *gorillæ*. Cerne has been considered as Arguin by D'Anville, and all the most eminent modern geographers. The approach to it by sailing two days west and one day east, and its situation in a recess of the sea, exactly correspond to the *Periplus*. The case is otherwise as to its magnitude, the circumference being stated at half a mile, while that of Arguin is five or six miles. But this may be an error in the text. Cornelius Nepos states it at twenty stadia, or two miles. Hanno calculates that Cerne is *opposite* to Carthage, which he explains, by saying that the distance from Carthage to the Straits is equal to that from the straits to Cerne. The latter space is considerably greater; but the estimate might very probably be made by following, according to the ancient mode of navigation, all the windings of the coast. It will then be found so much more deeply indented on the Mediterranean than on the Atlantic, that if the two spaces be thus examined, they will almost exactly coincide.

Rennell.

Major Rennell, (*Geog. Herodot*. sect. 19, 25), in treating of the important positions of Arguin and the Senegal, follows nearly the footsteps of Bougainville. But he ridicules the idea of ancient vessels sailing at the rate of seventy geographical miles in the day, which would be required, in order to reach, in twenty-six days, from Arguin to the Gulf of Benin. Such a rate would be considered rapid by modern ships, with every advantage of wind and tide. In the Gulfs of Bissao and Sherbro, he finds all the islands mentioned by Hanno, which cannot be satisfactorily placed upon any other system. He derives a curious argument, by applying, according to the literal sense of the *Periplus*, the term *Horn* to the bay itself, and not, as had usually been done, to the bounding cape. This form is certainly presented by the Gulfs of Bissago and Sherbro, and it does not occur on any other part of the coast.

In the voyage between the Straits and Cerne, Major Rennell justly reprobates the idea of five cities being founded beyond Cape Bojador, on the desert coast of the Sahara. Being unwilling, however, to admit the immense spaces of Bougainville, he is himself somewhat embarrassed by Scylax's estimate of twelve days sail from the Straits to Cerne, which would give a rate of 104 miles per day.

Gosselin.

The extent of M. Gosselin's scepticism will appear from looking at the table. Instead of a space of 3000 miles, which is assigned by Bougainville, and 2200 by Rennell, he does not extend the voyage beyond 640 miles; instead of carrying Hanno into the heart of Guinea, he scarcely allows him to have passed the limits of Morocco. In support of this opinion, he makes the following observations. (*Geog. des Anciens*, I. 60—164). Hanno's rate of sailing could not but be slow. He was upon an unknown sea, where numerous precautions were requisite;—upon a voyage of discovery, which called upon him to examine minutely every part of the coast, and to sail only during the day. He was attended also by a large and encumbered fleet, in

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which the slowest sailing vessel necessarily fixed the rate of the others. M. Gosselin thus conceives twenty miles a-day a very fair and probable average. He appeals to the difficulty which the Portuguese experienced in doubling Cape Bojador. After a series of fruitless attempts, they succeeded only by the aid of the compass, which enabled them to stand out to sea. Destitute of that instrument, Hanno, he insists, never could have overcome the formidable obstacles which there presented themselves. The important position of Soloe is distinctly stated by Herodotus as the western extremity of Africa, and the point at which the coast begins to take a southerly direction. This clearly points out Cape Spartel. The island of Fedala has precisely the dimensions assigned to Cerne, while those of Arguin totally differ. As to its equality of distance with Carthage from the Straits, he accounts for it by supposing, that on the known coast of the Mediterranean, vessels proceeded direct from cape to cape, while in an unknown sea, they would necessarily follow all the windings of the shore. The other islands mentioned by Hanno, he conceives to be merely shallows, inundated at high tides, as is proved by the salt water remaining upon them. To the objection that there are neither Ethiopians (negroes) nor crocodiles, nor hippopotami, nor ouran outangs now to be found in the kingdom of Morocco; he answers, that the term *Ethiopians* was not necessarily confined to negroes, but was extended to all people of a deep brown or olive complexion, and that the wild animals above mentioned formerly existed in this territory, whence they were expelled as the country became peopled.

In order to support this system, M. Gosselin has drawn forth and illustrated another curious document. This is the *Periplus* of Polybius, inserted by Pliny in the sixth book of his *Natural History*. The names are almost entirely changed from those of Hanno, which renders it difficult to compare the two together. A part of the distance, however, is given in Roman miles, which amount to 813, between the Straits and the Great Atlas. M. Gosselin then undertakes to prove, that this is not only the entire space passed over by Polybius, but that it equals the whole extent of the voyage of Hanno. Of this circumstance, indeed, Polybius himself is by no means aware. He states a great distance from the termination of his voyage to the *Chariot of the Gods*, and ten days from thence to the Western Horn. Our author, however, supposes, that not recognizing in the objects before him the wonders described by Hanno, he vaguely referred the latter to remote and still unexplored regions.

M. Gosselin has finally to combat the tables of Ptolemy, with which Major Rennell's ideas pretty nearly coincide, and which delineate an extent of coast, three times greater than he is willing to admit as having been known to the ancients. He contends, that, in all the ancient narratives, the names of places were assigned in a rude and careless manner, and that they were almost entirely different in different journals. He therefore infers, that Ptolemy might have perused three different voyages along precisely the same shores, and, from the names being different in each of the narratives, might thus be induced to delineate an extent of coast three times greater than was actually explored. Nothing can better evince the obscurity which hangs over the writings of the ancient geographers, than that it should be possible to adduce even plausible evidence of an error so singular. *

Progress of the Ancients along the Eastern Coast.

3. The extent of ancient discovery upon the *Eastern* coast of Africa, has divided the opinion of the learned, nearly as much as their progress along the west. All the earlier modern geographers extended it southwards, at least as far as Mosambique and the island of Madagascar. This opinion is supported by the respectable names of Sanson, Delisle, Huet, and Bochart. Vossius, however, in his notes on Pomponius Mela, expressed a doubt as to the discovery of Madagascar. The restriction was carried much farther by D'Anville, who limited the career of the ancients to Cape Delgado; and M. Gosselin, with that determined scepticism which characterizes his inquiries, has endeavoured, by many learned arguments, to prove, that these limits must be still farther restricted, and that the ancients never penetrated beyond Brava. On the other hand, Professor Vincent, in his very learned work on the *Periplus of the Erythrean Sea*, has sought anew to extend these boundaries to Mosambique, and perhaps to Madagascar. As Dr Vincent and M. Gosselin are the only authors who have made this question the subject of detailed and profound inquiry, it shall be our chief object to exhibit a comparative view of their respective systems.

The two main authorities on which the inquiry rests, are the particulars concerning this coast given by Ptolemy, and those found in the *Periplus* of the Erythrean sea. This last work, erroneously ascribed to Arrian of Nicomedia, contains the most detailed account that has descended to us of the navigation of the ancients in those seas. The two writers agree pretty nearly in their descriptions, though they differ frequently as to names. We have endeavoured, therefore, to illustrate the subject by the following table, which exhibits, 1. The description of the ports or stations. 2. The name in the *Periplus*. 3. The name in Ptolemy. 4. The modern position according to Gosselin. 5. The modern position according to Vincent.

* Without venturing upon any very decided opinion as to the comparative merits of these three systems, we would observe, that Bougainville appears to have given an extravagant extension to the voyage of Hanno, and that we think the system of Rennell the most conformable of any to the features of the coast as delineated in the *Periplus*. We confess, at the same time, that the short diurnal progress contended for by M. Gosselin appears better suited to all the circumstances and difficulties under which the voyage was performed; but this difficulty would be removed, if, as we incline to think, a day's sail among the ancients was always fixed to a certain extent, like a day's journey by land.

| Description of the Coast. | Ancient name in Periplus. | Ancient name in Ptolemy. | Modern Position according to Gosselin. | Modern Position according to Vincent. |
|---|---|---|---|---|
| The cape at which the coast turns to the south | Aromata | Aromata | C. Guardafui | C. Guardafui |
| A promontory and mart | Tabai | Pano Vicus | | C. d'Orfui |
| A considerable mart | Oponè | Oponè | | Baudel Caus |
| A promontory | | Zengifa | C. d'Orfui | Bandel D'Agoa |
| A mountain with three summits | | Phalangis mons | | Morro Cobir |
| Two successive gulfs | Apokapa the less | Apokapa | C. Delgado | Zorzella |
| | Apokapa the greater | Southern Horn | Bandel Cans | Cape Baxas |
| Azania | Little coast | Little coast | No objects | No objects except Magadoxo |
| | Great coast | Great coast | | |
| A port | | | Unknown | Brava |
| A promontory and port | Serapion | Serapion | C. Baxas | |
| A harbour | Nicon | Nici | | |
| Anchorages at mouths of rivers | Seven in succession | None mentioned | No traces to be found | Mouths of the Obii, or Quillimanci |
| Islands merely named | The Pyralaan | | Unnoticed | Formed by its branches at Melinda Mombaca, &c. |
| A low wooded island 300 stadia from land | Eitenenediom--Menouthesias (Menuthias) | Occurs afterwards | Misplaced | Monfia |
| A promontory and great emporium (termination of the Periplus) | Rhapta | Rhapton | Bandel veilho (mouth of the Doara) | Quiloa |
| An island 5° W. L. from Prasum | | Menuthias | Magadoxo | Madagascar |
| A promontory, port, and river, the limit of ancient knowledge on this side of the continent | | Prasum | Brava | Mosambique |

In forming his calculations, M. Gosselin (*Geographie des Anciens*, I. 165-198) considers that he is fully justified in resting chiefly on the authority of Ptolemy. That writer, from his residence at Alexandria, had an opportunity of examining personally the pilots who sailed upon those seas, and appears to have diligently employed his means of information. Following him, M. Gosselin states, that, owing to the variable nature of the winds, navigation is extremely slow in those latitudes; and that the space passed over in a night and day did not exceed 400 or 500 stadia. When a day's sail only is mentioned, he therefore estimates it at not more than 250 stadia, or 25 miles. Upon this principle, he finds 7500 stadia from Aromata to Rhapta. Examining the distances along the coast, he finds 8000 stadia between Cape Guardafui and the mouth of the Doara,—a very close approximation on so great a distance. Ptolemy, indeed, reckons Rhapta at about eight degrees of south latitude; but, in the first place, it is universally acknowledged that he has placed Aromata seven degrees too far south. Again, M. Gosselin conceives it to have been established that Ptolemy, following the error of Marinus, composed his degree of only 500 stadia, instead of the real number of 700. The degrees between Aromata and Rhapta must, therefore, be reduced two-sevenths. After these deductions are made, Rhapta will fall short of the equator, and nearly at the point to which we are conducted by the other species of measurement.

Dr Vincent, on the other hand, (*Periplus*, I. 69-166), prefers the *Periplus* to any other source of intelligence. It is evidently, he says, the testimony of an eye-witness who performed the voyage; it contains nothing marvellous or improbable, and its delineation of the coast corresponds better with that of modern navigators than any other account. He estimates the day's sail in that journal at 500 stadia, or 50 miles. Admitting Ptolemy's error as to the latitude of Aromata, he conceives that he corrected it in the course of the delineation. At Essina, under the line, the difference from Brava is only 1°. At Rhapta, the difference from Quiloa is not quite 10′. The graduated distance from Aromata to Rhapta, according to the *Periplus*, is 19° 45′. From Guardafui to Quiloa, according to D'Anville, is 20° 15′,—a coincidence almost too close. Still Dr Vincent rests his main argument on the correspondence of the features of the coast. He appeals, in particular, to the mention made in the *Periplus* of seven rivers, each at the distance of a day's sail from the other. This remarkable coincidence can be found nowhere, unless at the mouths of the great river Obii or Quillimanci, which lie far beyond M. Gosselin's limits. This proof does indeed seem pretty decisive; nor does that ingenious writer meet it with his usual intrepidity. He says, "The author of the *Periplus* speaks of seven other *harbours* which he does not name. No trace of them remains." But the words in the *Periplus* are express: Ποταμοι Πλειονες (*Geog. Græc. Minor.* I. 90.) The most formidable objection to this theory appears to be this, that the ancients should have passed all the three Zanzibar islands without making the slightest allusion, unless to one. This circumstance may have led Mr Pinkerton to fix upon Pemba as Menuthias. Mr Salt, who, with classical knowledge combined opportunities of observation which fall to the lot of few, expressed to us decidedly the same opinion. Pemba alone, he observed, corresponds exactly as to the

distance, the others being nearer. Mr Salt concurred also with D'Anville in viewing Cape Delgado as the Prasum of Ptolemy, and the farthest limit of ancient navigation.

Knowledge of the Ancients respecting the Interior of Africa.

4. We have now to consider the knowledge of the ancients relative to the *interior* of this great continent.

The coast of Africa, situated on the Mediterranean, was more completely and intimately known to the ancients than it has been to the geographers of modern Europe. Its connection with the states of Greece and Rome was so close, as to make it form only part, as it were, of the same system. As we advance into the interior, this knowledge becomes gradually more imperfect. Still, with regard to the countries watered by the Niger, it was perhaps, on the whole, superior to that possessed by Europeans down to the commencement of the present century.

So far back as the time of Herodotus, we find a notice respecting the *eastern* course of the Niger. That writer believed it to be the same river with the Nile,—an opinion still prevalent in Africa, though it appears to be erroneous. He also states a distinction between Africans and Ethiopians, which appears to coincide with the modern one between Moors and negroes. Beyond these few facts, the knowledge of Herodotus respecting the interior appears to have been exceedingly limited. War and commerce, however, gradually opened routes into these regions; and Alexandria, which became a great seat of geographical knowledge, afforded ample facilities for augmenting the stock of information. The best ancient description of the interior, is to be found in Ptolemy. It appears, however, that he was unacquainted with the extent of the *Sahara;* and, that he brought the territory of *Nigritia* much too near to the coast of the Mediterranean. His ideas, likewise, do not seem to have been very precise, in regard to the *Garamantes,* whom Rennell has upon good grounds placed in Fezzan, though we suspect the ancients must have extended the term to the nations inhabiting the valley of the *Gir.* But his geography displays an extensive and accurate acquaintance with the rivers of Africa. He has fixed the head of the Nile too far south indeed, and even beyond the equator; but he assigns to it its real origin among the Mountains of the Moon. It was by the *data* which he afforded, that D'Anville was enabled to ascertain the true sources of that great river. He has shewn that he was acquainted with the whole course of the Niger, and even with that of the Gambia and Senegal. He has not, however, thrown much light upon the celebrated question relative to the source and termination of the first mentioned stream: Major Rennell claims his suffrage to its eastern course, while Mr Pinkerton, perhaps rather more plausibly, charges him with giving it a western direction. So far as we can discover, Ptolemy did not pay the smallest attention to this circumstance, but considered merely the *line of river-course.* His general statement is, that the Niger "joins together mount Thala and mount Mandrus." (Lib. IV. cap. 6.) If Ptolemy annexed any precise meaning to this very singular description, it could only, we apprehend, be that of *two* rivers, flowing from opposite points into one common receptacle. He delineates also the course of another river called the *Gir,* almost equal to the *Niger,* and well known in ancient times. From its course and relative position to the Niger, there seems no room to hesitate in adopting the opinion of D'Anville and Rennell, that it is the river of Bornou, united, as we apprehend, with the Misselad of Browne, which we have no doubt is the same river, and forms certainly one continuous river-course.

Knowledge of the Arabians regarding Africa.

II. Among those branches of knowledge which were particularly encouraged by the Arabian princes, geography seems to have held a conspicuous place; and as Africa contained some of the chief seats of Musulman power, that continent attracted a great share of their attention. The Arabian geographers were thus led to give particular descriptions of some regions in the interior, which have never been visited by Europeans, and, in regard to which, they still remain almost our only authorities. These considerations have induced us to examine their writings with much care; and not having met with any systematic attempt to estimate the extent and value of their knowledge respecting central Africa, we hope that it will not be unacceptable to our readers to follow us into some details upon this curious subject.

We would observe in general, that the works of the Arabian geographers exhibit a remarkable mixture of correct and solid information, with meagre, unsatisfactory, and even fabulous details. The causes of some of these defects are clearly enough pointed out by themselves. Thus, Abulfeda complains, that it is "only the *Musulman* provinces which they describe with any degree of accuracy." (*Geogr. Græci Minores,* III. 21.) This, which to Abulfeda is a subject of regret, forms the glory of another Arabian geographer. "Of Christians and Ethiopians, says he, I have spoken little; for my innate love of justice, religion, and good government, made it impossible for me to find in these people any thing deserving of praise, or even of mention." (*Ibn Haukal, Oriental Geography.*) In fact the Saracens were in a state of habitual warfare with every other people. They were separated from them by a political and religious antipathy so deadly, as to exclude all interchange of ideas. The limit therefore of Moslem dominion will be always found to be likewise that of clear and accurate knowledge; after passing which, it gradually becomes faint, and gives place to fable and uncertainty.

A general impression seems to have prevailed, that Nubia was the point whence the information of the Arabians relative to central Africa was chiefly derived. This opinion rests solely on the belief of Sionita and Erpenius, that Nubia was the native country of Edrisi, the most copious of the Arabian writers on the subject of Africa. On that presumption, they published his work under the title of the *Nubian Geography,* which it still retains. This idea, is treated by Gibbon with great contempt, and completely refuted by Hartmann. (*Edrisi, Introd.* 49. &c.) In fact, there is scarcely any district of Africa, which is described in a manner so meagre and unsatisfactory by the Arabians, and above all by Edrisi himself. Nubia was

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Christian;* and was therefore a country shut against Mahometan Egypt. The merchants of each country, instead of travelling into the territory of the other, brought their commodities to the opposite sides of the great cataract, where, having landed and made the exchange, they immediately reimbarked. (*Edrisi*, 72.) But in the absence of this medium of information, the Arabians had opened for themselves another, nearly unknown to the ancients. At some period, not quite ascertained, they had penetrated across the great desert to the eastern shores of the Niger. Attracted by the fertility of its banks, and above all by its golden sands, they were not long of forming permanent settlements. Emigration and revolution continually swelled the tide; and in the course of one or two centuries, several great Mahometan kingdoms were established upon the Niger. Among these, Ghana, or Gana, held a decided pre-eminence. It was the nearest point to Northern Africa; and it bordered immediately on Wangara, whose soil the overflowing of the Niger annually impregnated with gold. A regular commercial intercourse was soon established with the other Musulman states; and caravans, in every direction, traversed the vast expanse of the desert. Gana became their point of rendezvous, and the grand emporium of central Africa. The splendour of its court is described in glowing terms by the Arabian writers. The palace, built upon the lake, was adorned with masterpieces of painting and sculpture, and with glass windows, then a rare object of luxury. The pomp of the sovereign is said to have surpassed that of any other Musulman potentate; and the circumstance, which above all excited admiration and envy, was a large mass of native gold, which was placed immediately under the throne. Many of the neighbouring states, among which Wangara is particularly mentioned, were numbered as his subjects or tributaries. (*Edrisi*, 41-7. *Ibn-al-Vardi, Notices*, II. 37.)

From these circumstances, it appears evident that Gana was the point whence chiefly emanated the knowledge of the Arabians relative to central Africa. It did not extend very far; for their settlements were then confined within narrower limits than now. Westwards, at the distance of about 400 miles, Tocrur and Sala are described as flourishing commercial cities, situated on the Niger, and governed by a Mahometan sovereign. They seem to have formed the limit of precise knowledge; but the necessity of procuring a supply of salt had given a further line of sixteen days' journey to Ulil; which Edrisi describes as an island situated in the sea, at one day's sail from the mouth of the *Nile of the negroes*, or Niger. It is now a very general, and, we apprehend, just opinion, that this *sea* of Edrisi must in fact have been an inland lake; and it seems, indeed, to be indicated as such by Scheabeddin. (*Notices*, II. 156.) The precise situation of this lake, and of the island of Ulil, will be a subject of future discussion. Meantime, we shall observe, that no supposition has extended it much to the west of Tombuctoo. The countries beyond, watered by the Senegal, the Gambia, and the part of the Niger visited by Europeans, were entirely unknown, and were viewed as a wide expanse of trackless desart.

To the east of Gana, the Arabs particularly describe Wangara, then celebrated over all Africa by the appellation of the "country of gold." They represent it as nearly surrounded by branches of the Nile, which overflow it during the rainy season; and as containing two lakes adjacent to the cities of Reghehil and Semegonda. Cauga (now Fittré) they appear also to have been well acquainted with, though there is some difference of opinion, whether it belonged to Wangara or to Canem, (now Bornou.) Eastward from thence, their knowledge becomes indistinct; and, before reaching Nubia, seems to cease entirely.

The settlements of the Arabs, as well as their geographical knowledge, extended but a short distance to the south of the Niger. The *Sahara* they seem to have traversed in almost every direction, setting out chiefly from its western extremity. Gadamis, Segelmessa, and Vareklan, (the last uncertain, but westmost of any,) are described as the customary routes, which led them to Gana, and the "land of gold." (*Bakui, Notices*, II. 400, 405. *Edrisi*, 133—135.)

In regard to the origin of the Nile, and the first part of its course, the Arabians were excluded from the opportunities of direct observation. We cannot, however, agree with Hartmann, in thinking that they derived it from Abyssinia, a country to which they were peculiarly strangers. We rather concur with Rennell and Pinkerton, who apprehend that their opinion nearly coincided with that of Ptolemy. The Arabians committed one very curious error, of which modern geographers have not been fully aware. They certainly considered the river of Bornou and the Nile of Egypt to be one and the same. Hartmann has remarked this in the case of Scheabeddin; but has not observed, that all the rest entertained the very same idea.† Nor will this appear very wonderful, when all the circumstances are taken into consideration. The Arabs knew little of Nubia, nor had traced the course of the Nile above its confluence with the Tacazze. (*Hartmann's Edrisi*, 75, 76.) Observing then a great river running through Barnon northwards, which could reach the sea only by uniting with the Nile, it was not a very strained supposition, that it might, at some point, take a direction westward, and effect the supposed junction. In consequence, however, of this opinion, the Arabs lost sight entirely of the *Gir* of Ptolemy, and recognized in Africa only two great rivers, the *Nile of Egypt*, and the *Nile of the Negroes*.

Parallel of

From the circumstances now stated, we may form

* See *Bakui in Notices des Manuscrits de la Bibliotheque du Roi*, II. 396. *Ibn-al-Vardi*. ib. 38.

† Abulfeda makes the Nile of Egypt pass through Zagava; for the position of which see Hartmann, 66-8. Ibn-al-Vardi (*Notices*, II. 36.) carries it through *Canem*, a district of Bornon. Compare also Hartmann. 64-5, and 56-7.

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their Geographical System with that of Ptolemy.

an estimate of the knowledge of the Arabian geographers compared with that of Ptolemy. The ancients evidently penetrated through Nubia, up the Nile, and thence westward along the Niger. Hence the great desert of Africa remained unexplored; for if an occasional adventurer made his way across it, no regular communication was ever established. But they enjoyed the opportunity of tracing the origin, course, and termination of all the great African rivers. Generally speaking, their range was wider, as it was not hemmed in on every side by religious antipathies. The Arabs had a different and more limited sphere of observation; but within it, their knowledge is more copious, precise, and satisfactory. Ptolemy's general ideas of central Africa are good; but he does not afford the means of fixing a single position; while the materials furnished by Edrisi have been familiarly used by the best modern geographers in the construction of maps of Africa. This does not, however, arise from any merit in the astronomical part of their geography, which, on the contrary, is extremely defective. But they investigated very diligently the distance of one place from another, by the reports of the caravan merchants;—a mode of intercourse which had already been established in Africa to such an extent, and conducted in so systematic a manner, as to afford very ample means of information. Edrisi's work, in this view, is particularly valuable. Major Rennell observes, that it is surprising how nearly his distances agree with those furnished by modern observations and inquiries.

The Arabs made little progress along the western coast of Africa; nor did their knowledge on that side equal that of the ancients. But the eastern coast, to an extent beyond any supposed limits of ancient discovery, was not only explored, but colonized by them. Flourishing settlements were established at Melinda, Mombaza, and at Sofala, called commonly the Golden Sofala. Vakvak, or Ouac Ouac, forms here the indistinct limit of knowledge. The Arabs not only had never passed the Cape of Good Hope, but had not even any idea of its existence. It appears, on the contrary, from the curious map of Edrisi, published by Dr Vincent, that, like Ptolemy, he extended it to the east, till it became conterminous with India and China. This explains his placing the islands of Vakvak in the sea of China;—a circumstance which causes much perplexity to Hartmann.

Early ideas entertained in Europe respecting the interior of Africa.

III. The period from the tenth to the fourteenth century, may be considered as the most flourishing era of Arabian science. From that time downwards, geographical discovery has been exclusively the boast of Europeans. The fifteenth century was a splendid era in maritime enterprise. Africa was then circumnavigated, its form ascertained, and its coasts visited and colonized. But the geography of its interior, instead of advancing, became decidedly retrograde. The Portuguese, who almost wholly engrossed this department of inquiry, penetrated only at the two opposite points of Abyssinia and Congo. By applying their observations upon these regions to almost the whole of Africa, and combining them with the often misunderstood notices of Edrisi, they formed a system materially erroneous. The Nile, instead of being traced, as in Ptolemy, to its real source, was supposed to rise in Abyssinia, and its southern and largest, as well as longest branch, which descends from the Mountains of the Moon, was thus overlooked. They did not, however, on that account, abridge in any degree the course of that celebrated river. They had extended Abyssinia immensely, so as to make it pass the southern frontier of Congo and Monomotapata, while the Mountains of the Moon were fixed mid-way between the tropic of Capricorn and the Cape of Good Hope. The lake Zambre (Dembea) was thus placed about 30° (upwards of 2000 miles) south of its real position,—was made the common source of the Nile, the Congo, and the Zambezi,—and was described as "the great mother and chief lady of all the African waters." * The Nile being thus derived from sources far beyond the equator, was considered as holding the longest course of any river in the known world. (*Ramusio*, I. 261.) The Niger still retained a mighty name among the streams of this continent; but no part of it had yet been exposed to European observation. Proceeding on the principles of Leo and Edrisi, the Gambia and Senegal were generally believed to be the two mouths, by which, after traversing nearly the whole breadth of Africa, it fell into the ocean. Some, following Edrisi's idea of its common source with the Nile, fixed upon the lake Dembea; the greater number, with Leo, derived it from a large lake to the south of Bornou; while some "holy men" are said to have numbered it as one of the branches of the Gion, which took this direction after issuing out of Paradise. (*Ludolfi Hist. Ethiop. Cadamosto in Ramusio.*)

The Portuguese.

About the commencement of the eighteenth century, the English and French began to form settlements on the Gambia and Senegal, and to ascend these rivers. This afforded to Europe a new channel of information relative to the interior of Africa. The most noted English traveller into the interior during that age was Francis Moore, an intelligent man, who, about 1720, spent several years on the Gambia. Fully impressed with the above-mentioned theory relative to the Niger, he pretends to find even on the Gambia, Edrisi's principal stations. Ulil is Joally, an island at the mouth of the river, which, it seems, really supplies its banks with salt; Sala is Barsally; Gana is Yani; and Wangara alone is higher than Europeans have yet reached. He was much disconcerted, however, by the intelligence brought down by Captain Stibbs, who had sailed sixty miles above Barraconda. This person reported, that the Senegal above Gallam became very small, while, as to the Gambia, twelve days above Barraconda, the natives assured him that "fowls walked over it." He therefore infers, that the source of these rivers is "nothing near so far in the country as by the geo-

* See Map in *Purchas's Pilgrims*, IV. p. 738; also descriptions of Lopez, Merolla, &c. Ibid IV. 773, 774; II. 1021. It is remarkable that Sanson's map, 1696, is constructed nearly on the above principles.

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graphers has been represented." As for the Niger, on being closely pressed, he fairly stated his opinion, " that there was no Niger at all." This decision, however, is very ill received by Moore, who asks if it is probable that both Leo and Edrisi " should affirm that there was so great a river as the Niger when there was no such river." (*Moore's Travels*, London, 1738, p. 298—306. App. p. 6.)

The French meanwhile were more active both in forming settlements and in making discoveries. Before 1714, they had gained such intelligence, as induced Delisle to construct his map of the world, with the Niger as a separate river from the Senegal, and flowing *westwards*. But it is to the Memoirs of D'Anville, read before the *Academie des Sciences*, about the year 1754, that we are to look for the first approaches to correct geography, in regard to the rivers of interior Africa. By combining the scanty notices of Ptolemy and Edrisi, with the narratives of modern travellers, he succeeded in forming an almost correct outline of African hydrography. He shewed the error into which the moderns had fallen, of conceiving the river of Abyssinia to be the Nile, and proved, both from the magnitude of the stream, and from ancient authority, the superior claims of the Bahr-el-Abiad. With regard to the Niger, instead of one great stream, running across Africa from east to west, and falling into the Atlantic, he recognizes three rivers, 1. The Senegal, well known, and distinct from the Niger; 2. The Niger itself; of which he says,—" We are actually informed, that the river of Senegal, considered hitherto as the lower part of the Niger, and its outlet into the ocean, is different from another river that lies deeper in the interior of Africa; and it is even inferred, from the report of the negroes, that this river flows in a direction contrary to that of the Senegal, or from west to east." He finds no ancient authority upon which to rest this opinion, except the single testimony of Herodotus. Upon this principle, however, he constructs his map, fixing the commencement of the Niger at the *Nigritis Palus* of Ptolemy, and its termination at the lake of Reghebil, in Wangara. 3. Another river, flowing in a contrary direction, on the opposite side of Africa, known now as the river of Bornou,—the *Gir* of Ptolemy, and, as D'Anville erroneously supposes, the " Nile of the Negroes" of Edrisi. He seems strongly impressed with the idea of a communication between this river and the Egyptian Nile, which, however, Browne's route has proved to be a mistake. D'Anville fails chiefly in regard to the geography of the Arabians, none of whose writings, except those of Edrisi, had been at that time translated. He unaccountably supposed that Edrisi describes two rivers under the names of the Niger, and the Nile of the Negroes; whereas, in fact, the latter is the term by which he designates the former; the word *Niger* nowhere occurring in his work. Hence, while D'Anville has designated one river (that of Bornou) as Edrisi's Nile of the Negroes, he has placed upon another all the countries and cities appropriated to it by that writer. Upon the whole, however, his map of central Africa is an admirable performance, and formed a new era in the geography of this continent.

D'Anville's system.

From this time, D'Anville's system, both with regard to the Nile and the Niger, was generally adopted by the higher class of geographers. Differences of opinion, however, still prevailed, and, in Britain particularly, a stand was long made for the system, which made the Gambia and Senegal the channels by which the Niger fell into the ocean. Kitchin, nevertheless, composed his map upon D'Anville's basis. In 1788, we find a Mr Barnes reporting to the Committee of Council on Africa, that " the Niger rises on the eastern extremity of the mountains of Govinea, and discharges itself into a large lake, the name of which he does not recollect." He was then asked as to " the transport of European goods *up* the Senegal and *down* the Niger, or of African goods *up* the Niger and *down* the Senegal"; (*Reports concerning the Trade to Africa, and particularly the Trade in Slaves*. 1788. Part I. *Slaves*); and thus it appears that the real state of this question was perfectly understood by the committee. During this period, however, an extreme apathy prevailed respecting the exploration of interior Africa; nor were any important contributions made to it, except those afforded by the travels of Mr Bruce. In this respect the African Association operated a most auspicious change, not only by their direct exertions, which were great, but by the enthusiasm which they kindled, and which led even private individuals to collect and communicate information on the subject. At the time when our former article was written, the result of this new impulse had already appeared in the travels of Park, Hornemann, and Browne, of which we there gave so copious an abstract, as to render any repetition unnecessary. It only remains to take a view of the discoveries, by no means unimportant, which have been since made; after which we shall be prepared to investigate those points of African geography which still remain unsettled and obscure.

Recent discoveries in Africa.

IV. 1. Some interesting information has been recently laid before the public concerning that part of Africa which lies northwards from the Cape of Good Hope, beyond the country of the Hottentots and Caffres. It was first visited by two gentlemen of the names of Trutter and Sommerville, the substance of whose observations is given by Mr Barrow in the Appendix to his *Voyage to Cochinchina*. The next visitor was Dr Lichtenstein, who communicated the result of his observations, first in the Weymar *Ephemerides*, and since more fully in the second volume of his *Travels in Africa*. Lastly, Dr Campbell, a missionary traveller, who penetrated to Leetakoo, has just given to the public a volume of travels in these regions.

Boshuanas.

The Boshuanas, Beetjuanas, or Bootchuanas, are a very numerous race, stated by Dr Lichtenstein to extend from the 25th to the 20th degree of south latitude, or, as he elsewhere expresses it, thirty or forty journeys north from the river Kuruhman. In fact, however, the northern limit has never been explored. They are evidently of the same stock with the Caffres, but do not quite equal them in bodily size and strength. On the other hand, they are much superior in civilization and the arts of life. They reside in towns of considerable magnitude. Leetakoo, ca-

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pital of the Matchappin tribe, has been most particularly described. Mr Barrow's informants reckoned the population at from 10,000 to 15,000 souls. Lichtenstein mentions, that, in consequence of the secession of part of the tribe, it had been reduced to less than half that number, and did not exceed 5000. Mr Campbell, however, counted 1500 houses, which, at five to each house, would give 7500, besides 1000 houses situated in the outposts. This calculation seems to have been very carefully made.

The Boshuanas are governed by a king, whose power is hereditary, and not subjected to any regular limits, though it is very mildly exercised. Quarrels are commonly decided by single combat, without his interference; but if the case is referred to him, he not only takes cognizance of it, but inflicts the punishment with his own hands. He commands in war, and his sons are employed in all the embassies to neighbouring states.

The Boshuanas pay considerable attention to agriculture; their fields are commonly fenced round; they cultivate the Caffre millet, two sorts of beans, gourds, and water melons. The labour, however, as usual among barbarous tribes, is performed by the women, who dig the ground with iron spades; the men merely guard the flocks, hunt, and go to war. Fish, though abundant, are viewed with abhorrence as an article of food. Their clothing consists entirely of the skins of animals, carefully tanned; and the greatest part of their body is covered. Their houses are circular, formed of the trunks and branches of the *Mimosa*, cemented within by a mixture of clay and cow-dung. There is an inner apartment for the family, and an outer one for slaves and domestics. Polygamy is generally practised; and it is common for the rich to have four or five wives. Mr Barrow asserts that there are no slaves; but this is expressly contradicted by Lichtenstein, who states that they are in considerable numbers, and assist the women in their labours, but are mildly treated.

The nation among themselves seem tranquil, mild, and courteous; but they are fond of war, which they carry on with ferocity. Their great object is to seize the cattle of their neighbours. Mr Campbell having, with a view to religious instruction, asked, "For what end man had been made?" the answer was, —"For plundering expeditions." After having killed an enemy, they carry off a small part of the flesh, which, at a solemn festival, they afterwards devour.

Wanketzens.

The tribe immediately south of Leetakoo, is the Wanketzens, said by Campbell to be more numerous, and to carry agriculture to higher perfection. Lichtenstein gives rather an opposite statement. The Morolongs, the Chojas, and the Marootzees, are also numbered among the most powerful and numerous of the Boshuan tribes. The Macquanas, however, the most distant, appear to surpass all the rest. They were described to Lichtenstein as like the sand in multitude, and their city is said by Mr Campbell to be three times the size of Leetakoo. They are particularly skilled in works in iron, and in the manufacture of arms. It was through them that the inhabitants of Leetakoo had first heard of white men;—probably the Portuguese on the east coast.

Expedition of Dr Cowan and Mr Denovan.

On the first news of these interesting discoveries, Lord Caledon, then governor of the Cape of Good Hope, took measures to extend them. With laudable zeal, he sent a party, consisting of Dr Cowan, Lieutenant Denovan, and twenty other persons, to explore Africa as far as Mosambique. The first accounts from them were favourable; but a silence of seven years afforded room for apprehensions, which were confirmed by the information collected by Mr Campbell at Leetakoo. After leaving that place, they had proceeded into the country of the Wanketzens, by whom they were at first well received. That people, however, whose character seems marked by ferocity and treachery, were only watching the opportunity of attack. Dr Cowan and Mr Denovan having imprudently gone to bathe, leaving part of their companions at the waggons, and another to guard the cattle, the natives took advantage of their separation; they attacked, first the party at the waggons, then those who guarded the cattle, and, last of all, the two chiefs of the expedition. The whole perished on the spot, with the exception of one, who also was afterwards taken and put to death.

In returning from Leetakoo, Mr Campbell crossed to the west coast, along the banks of the Orange river, a tract which had hitherto remained unexplored. He found it another *Sahara*, a complete desert of sand and rock. The rocks rise often in a perpendicular form resembling walls. One wall extended about thirty miles without interruption. A few kraals of Coranas are thinly scattered over this desolate region. The river seems on no occasion to overflow its banks, so as to communicate any fertility to this sandy waste. The country, for an unknown extent northwards, exhibits a similar aspect.

Mr Salt's account of the eastern coast of Africa.

2. The recent work of Mr Salt has thrown considerable light upon the geography of Eastern Africa, respecting which nothing authentic had been published for several centuries. That traveller visited the Portuguese settlements of Mosambique, Mesuril, and Sofala, which appear to have greatly declined from the importance which they once possessed. Mosambique is situate upon a small island, lying directly across the mouth of a deep bay. The situation is advantageous, and the place must have been once very strong; but the eighty pieces of cannon by which it is now defended are marked with the rust of antiquity; and the garrison consists of a few confined felons, and invalids. The population of the town of Mosambique is reckoned by Mr Salt at 2800, of whom 500 are Portuguese, 800 the descendants of Arab settlers, and Banians, and the rest Negroes. So slender and mixed a population is altogether inadequate to preserve the colony in a respectable state. The appointments of the governor and inferior officers are greatly too small, and expose them to the temptation of engaging in traffic, and other transactions ill suited to their station. Upon the whole, the state of affairs is such, that a trader at Mocha declared, that, with a hundred stout Arabian soldiers, he could dispossess the Portuguese of the colony.

Mosambique.

Mesuril.

There is also a government-house at Mesuril, a pleasant village, situated on the peninsula of Caboceiro, which lies opposite to the island of Mosam-

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bique, and supplies the town with most of the provisions consumed in it.

Sofala is described as a miserable village; but the country round is extremely fertile, and supplies exquisite fruits to the inhabitants of Mosambique. Small forts are also kept up at Inhambane and Cape Corrientes, for the purpose of collecting the ivory, which is abundantly supplied in the neighbouring forests.

The native race in the immediate neighbourhood of Mosambique is that of the Makooa, or Makooana, already alluded to. It comprises a number of very powerful tribes, extending southwards to Melinda, and north to the mouth of the river Zambezi. They are described as an athletic race of people, very warlike, and extremely hostile to the Portuguese. They sometimes carry their incursions even into the peninsula of Caboceiro. The Portuguese maintain their ground chiefly by alliances with other native tribes who are hostile to the Makooa.

The principal settlements of the Portuguese in the interior are on the great river Zambezi, the mouth of which is three or four days' sail from Mosambique. Sena, the capital of these settlements, lies about two hundred and forty-seven miles up the river, on its southern bank. It contains about two thousand inhabitants, and is protected by a strong fort. The principal mart for gold, however, is at Manica, about twenty days' journey south-west from Sena. About sixty leagues above Sena is Tête, which contains a depôt for merchandize, and is considered the best regulated settlement on the Zambezi. A month's journey beyond Tête is Zumbo, the remotest settlement of the Portuguese, and where it is only by the permission of the natives that they maintain a small factory.

Trade of Mosambique.

The trade of Mosambique has declined. Its exports consist of gold, ivory, and slaves. The annual number of the latter is stated at four thousand. This traffic, however, has diminished, in consequence of the British prohibition, which has shut the markets of the Cape of Good Hope, the Isles of France and Bourbon, and Batavia. Ivory and gold bear very high prices. The former is stated at from L. 24 to L. 21, 15s. per hundred. Gold dust is at L. 3, 5s. the ounce *avoirdupois*. Provisions are in abundance, and at a moderate rate. The imports consist of what is usually required in a tropical colony; articles of dress, furniture, and ornament; arms and ammunition; teas; and cloths. Four or five vessels come annually from the Portuguese settlements in Malabar; and it was thought that a small British cargo might also be disposed of in the months of April, May, or June. The duty on imports is twenty *per cent. ad valorem;* with other charges, which amount to about five *per cent.* more.

We were informed by Mr Salt, that the present maps and descriptions of the eastern part of the continent in general are almost wholly imaginary. Thus, the great empire of Monomuji, or Nimeamay, which is made to fill nearly the whole breadth of Africa, is derived from a tribe behind Mosambique, called the Monjous. That chain of mountains, which makes so conspicuous a figure in our maps, under the title of the *Spine of the World*, is not believed by Mr Salt to exist. He saw persons who came from the lake Maravi, without having encountered any mountains on their route. In general, Mr Salt observed that it was usual in this quarter to extend every district far beyond its actual limits. The names of small towns and villages are currently transferred to a vast extent of territory behind them. In this manner have been formed the *kingdoms* of Sofala, Inhambane, Mosambique, and Querimba. The kingdom of Adel, which makes so conspicuous a figure in the history and geography of Africa, does not appear to have any existence. Its alleged site is occupied by the tribes of the Somauli, concerning whom Mr Salt obtained much information, and who appear to have made considerable advances in civilization. The name of Adel seems derived from the tribes of the Adaiel, who inhabit, not the place assigned to that kingdom, but a more northern position on the shores of the bay of Zeila. Contiguous to them, on the west, is the kingdom of Hurrur, which seems generally associated with the Somauli in the wars carried on against Abyssinia.

Account of Bornou, collected by Dr Seetzen.

3. Dr Seetzen, a German physician residing at Alexandria, had lately an opportunity of receiving some information from two natives of the interior of Africa, who were on a pilgrimage to Mecca.* One of them, Abdallah, was a native of Bornou; the other, named Hassan, was from the western part of Darfoor. The former gave a very magnificent description, probably a good deal exaggerated, of his native country. The city of Bornou he represented to be of such magnitude, that "Cairo was a trifle compared to it;" and that a day was insufficient to travel from one end to the other. This great extension is probably produced by the irregular mode of building, not in streets, but by single houses, with gardens, and even fields intervening. The mosques are innumerable, built of stone, and mounted with towers, seven of which appear on the principal one. The schools are numerous in all the cities, particularly in Bornou. They are held in the mosques, and are supported at the expence of the Sultan. His palace is of immense extent, and he goes every Friday in state to the principal mosque, where he distributes alms to the indigent. Within a mile of Bornou there flows a river, which Abdallah described to be as large as the Nile, and, like it, to overflow its banks. It is navigated by vessels of considerable dimensions, carrying sails and oars. The soil is sandy, and requires irrigation; but it produces in abundance rice, and a great variety of vegetable productions. The forests are very extensive, and contain lions, oran-outangs, camelopards, and other wild animals. There are numerous negro and Abyssinian slaves, who, whenever they arrive, are converted to the Mahometan religion. This is effected by flagellation, which is continued until the person cries out, "Mahomet is the prophet of God;" when he is immediately ranked among sound Musulmen. Abdallah asserted also, that there were a few Christian slaves at Bornou.

Although Abdallah shews an evident disposition

* See *Malte-Brun Annales des Voyages*, XIX. 164—184. XXI. 145—179.

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to exalt his native country, there seems no doubt that Bornou is the most extensive and powerful kingdom of central Africa. Bergoo, Begherme, Wangara, and Cashna, are tributaries to its Sultan. He appears however, to boast of sway over regions to which his dominion has never really extended; as Hassan mentions among his subject countries Darfoor, Sennaar, and part of Barbary.

Bergoo.

From the native of Darfoor, some information was received concerning Bergoo, (which he called Mobba,) an extensive country between Bornou and Darfoor. It appears to be considerably inferior, both in populousness and civilization, to Bornou. The capital, Hara, or Wara, is about three times the size of Bulak, a suburb of Cairo. The houses are built of wood and earth; only some of the Darfoor merchants have them of stone. The inhabitants are chiefly Mahometan negroes. Natron and sal gem are produced in considerable quantities, and exported to Cairo. No grain is raised, except *durra* and *millet*, with each of which they make an intoxicating liquor. Three days' journey to the west of Wara, there passes a river, (doubtless the Misselad of Browne,) said to be larger than the Nile, and, like it, to overflow its banks.

Begherme.

Begherme is an extensive country, situated to the west of Bergoo, and, till of late, governed by its own Sultan, though dependent upon that of Bornou. According to the statement of Hassan, this monarch had espoused his sister. The Sultan of Bornou, scandalized by this incestuous connexion, sent orders to renounce it, or to await his vengeance. An insulting answer being returned, the offended sovereign immediately ordered his vassal, the Sultan of Mobba, (Bergoo,) to march his troops into Begherme, and annex it to his territories. The enterprize succeeded; the Sultan of Begherme was taken prisoner, and his dominions annexed to those of Bergoo.

Particulars respecting the Gold Coast.

4. The account of the Gold coast, published by Mr Meredith in 1812, exhibits a view of some important changes in the aspect of that part of Africa. The Fantees were known to be the principal people upon this coast; but immediately behind are the Ashantees, a more numerous and powerful nation, hitherto known only by report. It appears that they had long entertained a desire to open a communication with the coast, for which an opportunity was at last afforded. In 1806, two chiefs belonging to the kingdom of Assin, a dependence upon Ashantee, rebelled, and, being defeated, took refuge in the Fantee country. The Ashantee monarch pursued them; at the same time intimating, that he entertained no hostile views against the natives. The Fantees, however, joined their force to that of the fugitive chiefs; and a battle ensued, in which they were completely routed. The Ashantees marched down in triumph upon Anamaboe, where the English have one of their principal forts. In their way they destroyed the town of Cormantine, and possessed themselves of the Dutch fort there. The Anamaboes, meanwhile, used no means of defence, and suffered the Ashantee army to approach within three miles. The alarm being then given, all their forces were hastily collected; and the English, from the fort, witnessed, with no little anxiety, the action which followed. It quickly appeared that the Fantees were inferior, both in numbers and skill; and their army fled into the town in the utmost confusion. The Ashantees followed, and pursued them to the beach, where they vainly endeavoured to gain their vessels. A dreadful slaughter ensued, in which upwards of eight thousand are supposed to have perished. The English had imagined, that the mere discharge of a few cannon over their heads would have intimidated and deterred the Ashantees from entering the town; but, after accomplishing its destruction, these barbarians, undismayed, and upwards of twenty thousand strong, turned their arms against the fort. The garrison did not exceed fourteen men, and was soon reduced to eight. Yet such was the good condition of the fort, and the firmness of this small body, that, at the close of the day, they were still able to oppose a stout resistance; and the enemy, overawed by this vigorous defence, did not renew the attack on the following morning, nor even oppose the entrance of a small reinforcement from Cape Coast. A negociation having been opened, a treaty was soon concluded, and amicable visits interchanged. The Ashantees were found to be a people greatly superior to the Fantees, both in numbers and in civilization; and they seemed particularly anxious to open a commercial intercourse with the English. Want of provisions, and the inroads of disease, obliged them soon to return to their own country. They have since made several inroads, and particularly one, on a great scale, in 1811; but the Fantees, though always routed in the field, have hitherto succeeded, by their knowledge of the country, and other causes, in preventing them from forming any solid establishment.

Accounts of Tombuctoo.

5. The fullest description which has yet appeared of the great central city of Tombuctoo and its vicinity, is that appended to Mr Grey Jackson's *Account of the Empire of Morocco*. This narrative, perhaps too highly rated by some eminent critics, is regarded by others as utterly fabulous. The able editor of the lately published account of Park's last unfortunate expedition has wholly rejected Mr Jackson's details, upon the ground that they are solely derived from *native* travellers and merchants; and he broadly lays down the principle, that *African* evidence is not to be admitted in geographical disquisition. Were this rule admitted, all modern knowledge of central Africa, and, in particular, all the information collected by the African Association, with the single exception of Mr Park's communications, would fall to be thrown entirely aside; but we confess, that we cannot discover any good reason for such a sweeping proscription. The travelling merchants of Africa, though destitute of education, yet visiting a variety of countries, and being frequently placed in critical exigencies, acquire a cultivation of mind superior to that possessed by the same class in Europe. The general tests of evidence are, no doubt, to be carefully applied in regard to their communications. Attention must be paid to the qualifications of the narrator, to his means of knowledge, and to his having no interest in disguising the truth. It must be very desirable also to have more than one independent witness to the same fact. But, upon the whole, we scarcely recollect an instance in which the testimony

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of respectable Africans has proved materially erroneous.*

Tombuctoo, according to the information collected by Mr Jackson, is situate on a plain, surrounded by sandy eminences. The houses are spacious, and built in the quadrangular form. They have no upper apartments, nor even any windows, being lighted by throwing open the doors, which are wide and lofty.† The inhabitants are said to possess an elegance and suavity of manners not known in the north of Africa; and their attachment to their country is such, that they never fail to return to it as soon as circumstances permit. The police is excellent; it is managed by a divan of twelve *Alemma*, who are elected every three years, and then fall into the mass of the people. Toleration is said to be exercised towards every class except the Jews, who are either excluded from the city, or obliged, while in it, to adopt the outward profession of Mahometanism.

Among the commodities brought to Tombuctoo, Mr Jackson mentions gold rings of Wangara;—the first modern notice that has occurred to us of a trade so celebrated in the time of the Arabians. Mr Jackson mentions the countries of Lamlam and Melli, not in the erroneous position of Leo, but as fixed by the Arabs; and adds, that they are reported to be inhabited by one of the lost tribes of Israel. This report, which certainly savours of the marvellous, derives, however, some sort of countenance from the statements of Kircher and Edrisi,—purporting that a colony of Jews, which first settled on the shores of the Niger, afterwards removed to this country; flying probably before the arms of the Saracens. (*Hartmann*, 37.)

In regard to the sovereignty of Tombuctoo, Mr Jackson has committed at least an anachronism. He states, that, in 1800, it was subject to Woolo, king of Bambarra. But from Park it appears, that, in 1796 and 1805, the king of Bambarra was Mansong, and Tombuctoo independent. Isaaco's journal, to be afterwards noticed, indeed mentions, that Woolo (or Wolloo) was predecessor to Mansong, and a distinguished warrior; so that he *may* at one time have held Tombuctoo in subjection; but it could not be in 1800.

Mr Park's last Journey and death.

6. We shall conclude this part of our subject with some account of the last expedition of the great explorer of the interior of Africa. After a number of delays, occasioned by ministerial changes and official difficulties, Mr Park set sail on the 30th January 1805. On the 28th March he arrived in the road of Goree, and having made the necessary preparations, and engaged a body of men from the garrison to accompany him, he set out from Kayee on the 27th April following. He was obliged to remain six days at Pisania, in order to procure some articles, the necessity of which had not been foreseen. Proceeding thence on the 11th of May, he reached Madina, capital of the kingdom of Woolli, and on the 15th was on the banks of the Gambia. The weather had as yet been favourable; and no obstacle presented itself, unless from the eagerness of the natives to obtain a larger share than he could prudently give, of the valuable articles which he carried along with him. By a happy mixture, however, of firmness and moderation, he always succeeded in extricating himself from these embarrassments without coming to extremities. He left Bammakoo on the 13th of May, and for some time held a prosperous course. The men continued in good health, and two who had been affected with the dysentery, were fast recovering. But the rainy season at length approached, and those who were on the recovery speedily relapsed. In a few days twelve were on the sick list. No sooner was the expedition perceived to be in a sickly state, than the natives conceived hopes of turning it to their advantage. Clouds of thieves hovered round, and, at every moment of distress, rushed forward to snatch whatever had been left exposed. By the 6th of July the whole party were in a state of sickness, and several affected with mental derangement. On the 27th July four men lay down, and refused to go farther. Mr Park was himself very sick and faint, and seems to have been on the point of yielding to despair, when he was cheered with the view of some distant mountains to the south-east. "The certainty that the Niger washed the southern base of these mountains made him forget his fever; and he thought of nothing but how to climb over their blue summits." Three weeks more of incessant effort and distress brought him to the wished for object; for coming to the brow of a hill, he once more saw the Niger "rolling its immense stream along the plain."

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In this journey, Mr Park, after leaving the village of Fankia, changed his former route for one more to the north, through Konkodoo and Fooladoo, near the southern frontier of Kaarta. He does not state the reason, but his editor conjectures, with great likelihood, that it was to avoid the Jallonka wilderness. This new route gave him an opportunity of observing the process of washing for gold. A woman collected in a calabash a quantity of sand and water; and having cleared it of the large pebbles, agitated the whole with a rotatory motion. The baser particles being thus thrown out, a black substance remained, resembling gunpowder; this is called *gold rust*. On its being further agitated, yellow specks began to appear, which were the grains of gold. In two pounds of sand, twenty-three of these particles were found. The quantity of gold rust is in general forty times that of the gold. It was stated that pieces were sometimes obtained as large as the fist. Mr Park had afterwards an opportunity of seeing the mode of smelting and forming it into rings. It was performed by the mere action of fire, without any flux or mixture whatever.

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* This, of course, applies only to facts which have fallen under their sphere of observation; not to opinions, (such as that of the identity of the Nile and the Niger,) which relate to distant objects, and would require a large mass of evidence to enable them to decide.

† Captain Blankett states, on the contrary, that they are two or three stories high. *Report of Committee of Council on Africa*, &c. 1788.

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Mr Park was particularly struck with the scenery of Dindikoo. The villages on the mountains, he says, are romantic beyond any thing he ever saw. "They are built in the most delightful glens; and while the thunder rolls in awful grandeur over their heads, they can look from their tremendous precipices over all the wild and woody plain, which extends from the Faleme to the Black river."

Mr Park arrived on the Niger in a situation, and with prospects, far different from those which he had fondly anticipated. Of forty-four persons whom he had brought with him from Pisania, there remained only six soldiers, and one carpenter, all in the most infirm state of health, and one of them deranged. Such circumstances might well have deterred the boldest spirit from plunging farther into the depths of unknown and hostile regions. But Park never seems to have felt a moment's hesitation. As soon as a canoe could be hired, he set sail for Marraboo, where he arrived on the 23d. He then sent forward his guide Isaaco to Sego, to request of Mansong, king of Bambarra, permission to pass through his territories. Mansong immediately dispatched his prime-minister Modibinne, to ask his motives for coming into Bambarra. Park made a very judicious reply, in which he particularly set forth the advantages which Bambarra would receive from the direct importation of English goods, instead of receiving them by the circuitous route of Morocco and Tombuctoo. Mansong, whose whole conduct seems to have been liberal, soon returned an answer, in which he gave full permission to travel through his dominions in any direction, and to build boats at whatever point might be deemed most advisable. No wish, however, being expressed for a personal interview, Park immediately proceeded to Sansanding, which he fixed upon for the construction of his vessel. Here he resided for two months, and enjoyed a better opportunity than had ever before occurred, of observing the economy of an African city, and the mode of conducting trade in this part of the continent. The result exhibits a favourable view of its progress in civilization. The arrangements for the convenience of trade, and the division of employments, appear to be carried to greater perfection, than in any European town of the same magnitude. The market-place is a large square, and the stalls on which the different articles are exposed, are shaded by mats from the heat of the sun. In general, each stall is appropriated to a single commodity. Some contain beads; others indigo; others wood-ashes; and one was observed with nothing but antimony in small bits. Other articles enumerated are salt, scarlet, tobacco, amber, silks from Morocco, sulphur, copper, and silver rings, and bracelets. A table is also given of the prices which different goods bore at this market, and it is so novel and curious, that we shall make some extracts from it.

| | *Value in Cowries.* |
|---|---|
| A musket, | 6 to 7000 |
| A cutlass, | 1500 to 2000 |
| A flint, | 40 |
| Gunpowder, one bottle, | 3000 |
| Amber, No. 1 to 6, | 60 to 1000 |
| Coral each stone, | 60 |
| An Indian baft | 20,000 |
| Scarlet cloth, 10 spans, | 20,000 |
| If sold to the Karankeas in retail, | 30,000 |
| Light *yellow* cloth, nearly the same as scarlet; *blue*, not so high. | |
| Paper, per sheet, | 40 |
| AFRICAN PRODUCE. | |
| A minkalli of gold (12s. 6d. Sterling) | 3000 |
| *Ivory*, the very largest teeth, each, | 10,000 |
| *Ivory*, the medium size, | 7000 |
| —— the smaller, | 3 or 4000 |

Mr Park here learned, that a large river called the Ba Nimma, from the Kong mountains, falls into the lake Dibbie. It is not quite half the size of the Joliba, and receives a smaller stream, called the Ba Miniana. Jinnie is not situated on the Niger, but at the confluence of the Nimma and Miniana. He learned that the northern bank of the river was occupied by the Moors at Tombuctoo only, and in other places by native tribes, called the Soorka, Mahinga, and Tuarick.

In the course of his residence here, five more of the party died, among whom was Mr Alexander Anderson, his near relation and intimate friend, whose fate he deplores in the most pathetic terms. "No event," says he, "which took place during the journey, ever threw the smallest gloom over my mind, till I laid Mr Anderson in the grave. I then felt myself as if left a second time lonely and friendless among the wilds of Africa." He had now with him only Lieutenant Martyn, and three soldiers, of whom one was deranged; yet he writes to Lord Camden: "Though all the Europeans who are with me should die, and though I were myself half dead, I would still persevere."—"I shall set sail to the east with the fixed resolution to discover the termination of the Niger, or perish in the attempt." One circumstance which tended to confirm him in this enthusiastic determination, was an opinion which he had eagerly imbibed, that the Niger was the same river with the Congo, and that a few months navigation down its stream would bring him to the Atlantic.

Park sailed from Sansanding; and accounts of his progress were long anxiously looked for. It was not till 1806, that some unfavourable rumours reached the coast by means of the native traders. As these gradually increased, Governor Maxwell, with a laudable anxiety, began to consider the means of inquiring into their truth; and he was fortunate enough to engage the guide Isaaco, to proceed on an expedition of inquiry. It so happened, that Isaaco, near Sansanding, met with a person named Amadi Fatouma, whom Park had taken with him as a guide down the Niger. From him he received a journal containing the particulars of the death of Mr Park. The correctness of this narrative, as well as the fidelity of the guide, have been called in question on very plausible grounds. But the great length of time which has now elapsed, renders it vain to doubt that this illustrious traveller must have perished on his voyage down the Niger.

V. We shall now take a view of the questions Of the

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doubtful and disputed points in African Geography.

which yet remain to be solved in regard to the geography of this continent. These may be chiefly classed under the three following heads: 1. The course of the Niger *beyond* Tombuctoo, and its *termination*. 2. The course of the river, called by Ptolemy, the *Gir*. 3. The precise source of the Egyptian Nile, and its communication, if any, with the Niger.

The course and termination of the Niger.

1. The Niger, according to the information of Mr Park and Major Houghton, rises at Sankari, in the high country on the frontier of Manding. Thence it is ascertained, by ocular observation, to pursue a course of about three hundred miles to Silla. Then, by undoubted information, it flows four hundred miles farther to Houssa. Positive testimony here deserts us, unless at the single point of the ferry in Cassina; but all accounts, both ancient and modern, seem to agree in stating, that there is a continuous river-course from thence to the eastern extremity of Wangara, being nine hundred and seventy geographical miles; which makes an entire course of sixteen hundred and seventy. (*Rennell, Illustrations of Park*, chap. vi.) In Wangara it forms several lakes, and that country is entirely surrounded and intersected by its branches. It would appear from Edrisi, as if there were a communication between these waters and the lake of Kauga, undoubtedly the same described to Mr Browne under the name of Fittré.

Major Rennell's Hypothesis.

There is thus no doubt of a continued stream from the source of the Niger in Manding, to the eastern extremity of Wangara. The next question is as to the direction in which it flows. This is established to be from west to east, by ocular observation, as far as Silla; by highly probable evidence as far as Houssa; and Major Rennell undertakes to prove that it follows the same course as far as Wangara. He quotes the testimony of a Moorish merchant, who had visited Houssa, and told Mr Beaufoy, that persons sailed thence to Ghinny (Gana) still *with the stream*. The description given by Edrisi, of Wangara, and partly also of Gana, is that of a country environed, intersected, and, during the rainy season, inundated by the waters of the Niger. These waters, therefore, spread over this extensive surface, and partly formed into lakes, may, he conceives, be entirely evaporated. It is possible, however, that a part may flow still farther eastward, and be lost in the lake of Fittré. (*Illustrations of Hornemann*, chap. 3.)

Hypothesis of Mr Maxwell and Park.

This opinion, at one time generally received, has of late been strongly controverted, and other conjectures of a very opposite nature brought forward. One, which seems very prevalent in Africa, is, that the Niger flows eastward, till it joins the Egyptian Nile, with which it forms one and the same river. We shall reserve, till we treat of the Nile itself, the reasons which seem to throw just discredit upon this opinion. But another hypothesis, which has just attracted great attention, is that so zealously adopted by Mr Park,—the hypothesis that it joins the Congo, or Zaire. This opinion certainly deserves consideration, both from the great name by which it is supported, and from the influence it may have upon future enterprizes of discovery. We may premise, that Mr Park's opinion was not derived from any facts observed by himself, but was adopted from a Mr Maxwell, an African trader, who had examined the Congo, and made a chart of its lower extremity. *

The first ground on which the Congo is identified with the Niger is its magnitude, which seems indeed to be stupendous. It is stated to be ten miles broad near its mouth, and the flood which it discharges into the sea to freshen the waters for upwards of thirty miles. These facts, which had been nearly forgotten in Europe, were well known and repeated, even with exaggeration, by the Portuguese, during their era of discovery. Lopez and Merolla describe it as almost thirty miles broad at its entrance, and as freshening the waters to the distance sometimes of eighty miles. (*Astley's Collection*, III. 236.) It is farther stated by Mr Maxwell, that it swells considerably, some time after the Niger is in flood, and before any rains have fallen to the south of the equator. Hence, he infers, that its sources lie far to the north; and this, combined with its extraordinary magnitude, and the mystery which involves the termination of the Niger, is conceived to establish a strong probability, that the two rivers are one and the same.

Objections to this Hypothesis.

To this hypothesis it is objected by the able editor of Park's last Journal, that we should thus assign to the Niger a course of upwards of 4000 miles; a highly improbable length, and which would make it by much the largest river in the known world. But this argument does not appear to us decisive, since a great river, once formed, must continue to flow till it finds a receptacle. We attach much more importance to the next observation,—that the Niger could not reach the Congo but by crossing that great central chain of mountains, which, according to various concurrent testimonies, extends across the whole breadth of Africa. † It cannot be denied indeed, that so powerful an agent might effect a breach even in the most formidable mountain wall. Both the Indus and the Ganges cross the limitary chains of Indostan in their way to the ocean. But the important consideration appears to us to be, that so great a chain as that which crosses Africa is always found to rest on a very elevated base. The Indian rivers have their rise and *early course* along the *highest* table-land of Asia, which leaves only the mountain barrier to penetrate. It seems inconceivable, how the Niger, after *descending* for more than a thousand miles along the level plain of Nigritia, should ever reach the elevated

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* For a full account of this hypothesis, and the observations and reasonings by which it is supported, see *Quarterly Review*, Vol. XIII. p. 120-51.

† The observations of Mr Park, corroborated by the succession of rivers from the south falling into the Joliba and Dibbie, extend it from Sierra Leone to nearly opposite Tombuctoo. Thence the evidence collected by the Association, (1790, ch. 8.) carry it west as far as Cassina. Ptolemy, Leo, and Edrisi, unite in describing Wangara as barred on the south by very lofty mountains. We are thus led to that portion, the most elevated of all, which gives rise to the Nile, and extends through Abyssinia to the Arabian Gulf.

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*plateau* on which such a chain must rest. We may likewise observe, that there is a total absence of all testimony, even the faintest rumour, in favour of this hypothesis. Yet both Ptolemy and the Arabians were well acquainted with the rivers of Wangara, and the extensive knowledge possessed by the former renders his silence, of itself, nearly decisive as to this question.

Let us now consider, whether this hypothesis is calculated, or is necessary, to account for the flooding of the Congo. It supposes, that the autumnal swell of this river is produced, like that of the Nile, by the rains of the northern tropic. Congo, too, being about the same distance with Egypt from the region of these rains, (which are bounded on one side by the equator, on the other by the tropic) it follows, that the Niger, in Congo, ought to exhibit very nearly the same phenomena as the Nile in Egypt. The magnitude of the rise, and its period, ought to be as nearly as possible the same. The average rise of the Nile is stated at thirty feet, which is also that of the Ganges, the Senegal, and, we believe, of all the great rivers fed by the rains of the northern tropic. The Niger-Congo, which has three-fourths of its immense course through the region of these rains, ought unquestionably to experience an equal rise. We learn, on the contrary, from Mr Maxwell himself, that it never exceeds *nine* feet, not a third of that which takes place in the other streams. It thus produces no remarkable effect on the aspect of the river, which in September, when at the lowest, exhibits all the appearances of full flood. There seems no conceivable reason, why the same cause, acting in circumstances so nearly similar, should produce an effect so greatly different.

Let us now consider the period. The tropical rains commence early in June. On the 17th the Nile begins to rise, and by the beginning of August all Egypt is laid under water. The Niger-Congo, indeed, would double the length of the Nile, and, though both its portions are much more rapid, we are willing to allow it double the period. The current of the Congo exceeds six miles an hour,—the usual rate, we believe, of *flood current*. This would carry the rise, from its source to its *embouchure*, in somewhat less than a month. The fact, however, is, according to Mr Maxwell's statement, that not the slightest rise takes place till the end of September, nearly four months after the northern rains have set in, at a period when these rains have entirely ceased, and when the Nile, after three months of inundation, has begun to retire. The discrepancy, therefore, is as complete with regard to the period as to the magnitude; and the Congo, instead of exhibiting, as has been imagined, phenomena which imply a connection with the Niger, presents none that do not run directly counter to such a supposition.

Having thus proved that the floods of the Congo bear no correspondence to those of any river passing through the northern tropic, it can scarcely be required, that, with such imperfect means, we should attempt to investigate their real causes. Were we called upon to form a conjecture, we should, with great diffidence, state the following: The perennial fulness of the Congo may easily be accounted for by supposing it to be fed from the region of perpetual rain immediately under the line. In fact, its direction from the E. N. E. would lead our views to this very quarter, and particularly to the southern side of that mighty chain, which pours down the Abiad, the Misselad, and other great streams of northern Africa. This would give also a very long course to account for its magnitude. The floods and tornadoes, which, in the region above mentioned, are never wholly intermitted, experience an increase of violence, as the sun passes the equinox, which seems sufficient to account for the slight swells which, in March and September, take place upon the Congo. Their period and magnitude do not seem to indicate the action even of the south tropical rains. The Portuguese, indeed, describe the main branch of the Congo as flowing from the south; but probably upon very imperfect information; perhaps solely from their erroneous ideas relative to the position of the Dembea, its imagined source. D'Anville, in his map prefixed to Labat's *Ethiopie Occidentale*, observes, that the course of all the rivers which combine in forming the Congo or Zaire, is extremely uncertain.

Upon the whole, then, when we consider that this hypothesis rests upon no evidence whatever, but is contradicted by the statements of well-informed writers; that it is inconsistent with the probable structure of the African continent, and completely so with the actual phenomena of the Congo, as reported by the author of the hypothesis himself; we cannot see any ground on which it can be retained, even as a plausible conjecture, in geographical science.

M. Reichard's Hypothesis.

Another hypothesis, nearly similar, is advanced by M. Reichard, an eminent German geographer, who makes the Niger to fall into the sea, through a number of estuaries, not yet explored, in the Gulf of Benin. But this, though a more plausible notion, is wholly destitute of any positive evidence in its favour; it is equally liable with the former hypothesis to the objections arising from the direction of the great central chain of mountains; and besides, the supposition that the estuaries in question form branches of *one* great river, is purely conjectural.

Reverting then to Major Rennell's hypothesis: He supposes, that the Niger, after a long easterly course from Tombuctoo, loses itself among the lakes of Wangara. To this account of its termination it has been strongly objected, that there is no receptacle or lake in Wangara, sufficient for the vast mass of waters which must thus be supposed to flow into it. But that *lakes* do exist in that country, is made certain by the accounts of the Arabian writers; and as none of these writers, whatever M. Reichard may imagine, give any precise statements as to their *magnitude*, there is thus room to suppose, that some of them may be large enough to receive the waters of this mighty river. Were we therefore obliged to make a choice among these hypotheses, we should undoubtedly prefer Major Rennell's, as on the whole, the most probable. Our researches, however, have led us to form a hypothesis of our own; and we shall now proceed to explain it, in the hope of at least being able to bring into view some curious facts which seem to have been overlooked in the discussion of this interesting question.

New Hypothesis respecting the Termination of the Niger.

Briefly, then, our idea is this—That the great river-course which stretches across Africa consists in fact of *two rivers*, to both of which the name of *Niger* has been given; that one of these flows *eastward* by Sego and Tombuctoo, the other *westward* through Wangara and Cassina; and that these two rivers, at some intermediate point, not far from the modern position of Houssa, unite in a common receptacle.

The first question, then, relates to the course of that portion of the Niger which passes through Cassina, a country whose limits include the kingdom so celebrated by the Arabians, under the appellation of Gana. The flourishing states which the Arabs had founded in these regions, and the extensive trade which they carried on, gave them copious means of information. Now, these writers decidedly and repeatedly state, conformably to our hypothesis, that the great river flowing through this part of Africa, and which they call "the *Nile of the Negroes*," runs *westward*. * Major Rennell indeed supposes, that this idea may have been formed by unduly extending some rivers to the west of Nubia. But we have already shewn, that Nubia was very imperfectly, and the countries to the west of it scarcely at all, known to the Arabians. Gana, the metropolis of their empire, the emporium of their commerce, itself situate on the Niger, was doubtless the central point whence their information respecting that river would be derived. Abulfeda uniformly calls it the *Nile of Gana*. It appears, therefore, very improbable that they should not have been aware how the fact stood *at Gana*; and we cannot see that it ought to discredit their authority, though they should make it flow in the same direction, through countries not Mahometan, and thus lying beyond their sphere of observation.

The only modern testimony of an eye-witness, to the course of the Niger through Cassina, is that of the Shereef Imhammed, from whose information chiefly Mr Beaufoy compiled his account of Bornou and Soudan, published in the *Proceedings of the African Association*, 1790. From the circumstances there mentioned, as well as from the coincidence of his statements with the most authentic of those received from other quarters, there seems every reason to consider his authority as respectable. † As this person travelled in the countries south of the Niger, he must have passed it at least twice, in going and returning; and the prodigious rapidity which he ascribes to the current, would render a mistake as to its direction impossible. His report is decided, that its course is from *east to west*.

Niebhur, while in Egypt, collected some valuable information from the mouth of a native African, which he published in the *German Museum*; but as that work does not seem to have reached this country, we know it only by the extracts of Hartmann. It appears, however, that he is referred to only for the eastern part of the Niger, and that he states, as beyond all doubt, the *western* course of that river.

To this weight of ocular and historical testimony, nothing stands opposed, except the hearsay, somewhat vague, of a Moorish merchant, who had not travelled beyond Houssa. ‡ The Niger probably flows *east* for some distance after passing that city; a circumstance which might easily give rise to the report which the merchant received.

In support, however, of his opinion, that the Niger flows *eastward* through *Cassina to the lakes of Wangara*, Major Rennell urges an argument which certainly calls for consideration. If this river of Cassina flows *westward*, there must be a common receptacle between that place and Tombuctoo; and "we have not," says he, "heard of any such." (*Illustrations of Park*, chap. 2.) It may first be observed, that the tract is so completely unknown, that a receptacle might very well be supposed to exist there without any report of it being received. But we are moreover convinced, that, by diligently comparing ancient and modern accounts, we shall arrive at almost complete evidence of the existence, in this quarter, of a great lake, or inland sea, sufficient to form such a receptacle. The subject being curious, both in itself, and as connected with the question of the Niger, our readers may not be displeased to see these testimonies collected.

It seems to be now a general opinion among the best informed geographers of the present day, that the *sea* of the Arabians, into which they describe the *Nile of the Negroes* to fall, must have been a great lake, (*Hartmann*, 30. *Pinkerton*, II. 773.) In fact, the Arabic term rendered *sea*, signifies merely *great water*. It may therefore have been used in the latter signification, § and was certainly so understood by one Arabian writer, (*Scheabeddin*, *Notices*, II.

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* Edrisi, and Abulfeda, *passim*. Scheabeddin in *Notices*, Vol. II. 156.

† A very recent confirmation has been afforded in the concurrence of his description of Ashantee, or Assente, with that contained in the valuable work of Mr Meredith.

‡ This person's testimony would fall entirely, if it should prove true, that there is no such city as Houssa. (See Rennell on Hornemann, 185.) We must confess, however, our own opinion to be in favour of its existence, which seems supported by ocular testimony, while it is denied only by persons at a distance. But whenever Houssa is mentioned in this discussion, the *site* fixed by Major Rennell is meant, whether there be a city upon it or not.

§ To conceal nothing, we incline to suspect that this was not the case with Edrisi, but that, finding a great expanse of water at the extremity of African knowledge, he concluded it to be the ocean. He says, the Niger flows to the extremity of the west, p. 12. See also Dr Vincent's map. Ulil, a point situated on the opposite coast, might then be mistaken for an island. This will agree with Ibn-al-Vardi, a subsequent writer, who makes it a great city on the shore of the sea (or lake). It is certain that Edrisi gives *land* and *caravan* routes from Ulil to the principal cities of Africa. But, as he was not a person of very great

156.) There has not hitherto, however, been any attempt made to fix the position of this lake, according to the materials furnished by the Arabians, although their information seems sufficiently clear and precise. As Edrisi has given the routes from Ulil to several of the great cities of Africa, this will furnish the means of an approximation to its site. The route from Gana, westward, is given as follows:—To Berissa, twelve days' journey; to Tocrur and Sala, twelve; to Ulil, sixteen; in all, forty. Ulil is also said to be at the distance of a day's sail (or 100 miles) * from the mouth of the Nile, (*Edrisi*, 29-35.) The forty days from Gana, extended in a direct line, would reach to the vicinity of Tombuctoo, but would fall short of the eastern point of the lake Dibbie, much more of a day's sail beyond it. But a variety of details given by the Arabian writers fix the position much farther to the east, and even somewhat short of the reported site of Houssa. Ulil is said to be the capital of Maghrara, or Mekzara, an extensive tract of desert, south of the Niger, immediately bordering on Lamlam, and even on Gana. † Scheabeddin states the Niger to flow not to the ocean, but to the extremity of the inhabited part of Djenawa (Gana.) At this point, accordingly, Major Rennell, in his map 1790, has laid down a desert of ten journeys or more, on the authority of Imhammed. Ulil, however, is still more precisely fixed by the assigned distance (*Edrisi*, 40) from Audagost (Agades) of *one month*, which, in the most direct line, would not reach beyond Houssa, and supposing a probable deflexion to the south, would fall several days short of it. There remains, indeed, the difficulty of the forty days from Gana, which, as already observed, would, in a direct line, reach considerably farther west. But routes along rivers are naturally winding; and the present being apparently a land route, must, in that case, have made a considerable circuit round the shores of the lake. Agades being an ascertained position, ‡ the distance from it appears to be decisive.

From these collected statements, we may consider it as the clear and united testimony of the Arabian writers, that, in an extensive tract of desert, immediately to the east of the modern position of Houssa, there exists a great lake, or inland sea, which receives the eastern branch of the Niger. § We shall now advert to the modern authorities. Down to the period of the African Association, report is silent, which cannot at all be wondered at, as no traveller ever approached that part of Africa; and it was only learned by imperfect rumour that Tombuctoo was still in existence. It is remarkable, however, that, in the old maps by Purchas and Dapper, (followed in this respect by Sanson, and by Delisle in his earlier maps) there is uniformly laid down, at the very point we have traced, an immense lake, under the appellation of the Lake of Guarda. Upon what authority this lake is so placed, has completely eluded our research. It certainly was not that of the Arabians, whose *sea* was then universally understood to be the ocean. It therefore must have been originally laid down by the Portuguese, and it seems improbable that they should have done so without some kind of authority.

In consequence of the active spirit of discovery which has been roused by the Association, more distinct notices have begun to be received. Ben Ali, from whose information partly, the report 1790 was drawn up, heard it stated at Tombuctoo, that the Niger terminated in "a lake in the desert;" which is elsewhere expressed by saying that it was "lost in the sands to the south of Tombuctoo." (*Report* 1790, p. 222, and 1798, p. 143.) Major Rennel endeavours, consistently with his hypothesis as to the termination of the Niger, to apply this to Wangara; but no country on earth bears so little analogy to sand or desert; and it is far too distant to make the term "south of Tombuctoo" at all applicable. The report, on the contrary, agrees exactly with the Arabian notices.

Mr Jackson expressly states, that "fifteen journeys to the *east* of Tombuctoo, (that is, three or four beyond Houssa) there is an immense lake called the "Bahar Soudan, or Sea of Soudan." In describing the boundaries of Tombuctoo, he again mentions it as "a lake formed by the waters of the Nile Abeede, of which the opposite shore is not visible." He mentions a number of particulars respecting it; describes it as inhabited by a particular race of people, to be presently noticed, who navigate it with large decked vessels, || containing from 100 to 150 men, which have sometimes made their appearance at Tombuctoo.

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reflection, we suspect that, upon receiving these routes from the merchants, he might insert them, without embarrassing himself as to their consistency with his ideas of the situation of Ulil.

* So understood by D'Herbelot, *Bibliotheque Orientale*, art. Ulil. See also *Hartmann*, Introd. 119.

† *Edrisi*, 28, 36, 41. *Ibn-al-Vardi*, *Notices*, II. 351.

‡ See the data on which Major Rennell fixes it, *Afric. Assoc.* 1790, p. 119, 120.

§ The *salt-pits* of Ulil have been a subject of perplexity to modern geographers, as Nigritia has always been dependent for that article upon the interior of the desert. Considering that the knowledge of the Arabians expired here, it appears to us a very easy supposition, that Ulil, a great commercial city, (as it is described by Ibn-al-Vardi) might, in consequence of becoming a mart for the salt of the desert, be supposed to produce it. Cadamosto, in fact, describes a great salt trade upon this very line, from Tegazza, by Tombuctoo, towards Melli. *Ramusio*, I. 100. He adds, that the exchange was conducted on the bank of a great water, which might have been supposed the *sea*, had it been salt; that large boats came from certain *islands*, &c. The period of thirty days' travelling from Tombuctoo is too great; but when we consider that the salt was carried on mens' shoulders under a burning sun, they may well be supposed not to exceed half the rate of camel travelling. There seems, therefore, on the whole, a great coincidence with Edrisi.

|| The *barche grandi* of Cadamosto? We find no mention of any other kind of vessels than canoes on any other part of the Niger.

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Mr Park, during his first journey, received no accounts of any lake beyond the Dibbie. But during his last residence of two months at Sansanding, he obtained the following information: "One month's travel south of Baedoo, *through the kingdom of Gotto*, will bring the traveller to the country of the Christians, who have their houses on the banks of the *Ba Sea Feena;* this water they describe as *incomparably larger* than the Dibbie, and that it flows sometimes one way, and sometimes another." (p. 168). The expression "south of Baedoo" must either be a mistake, or understood in a very qualified sense, as the kingdom of Gotto extends *eastward* along the course of the Niger. Now, from Sansanding to Silla, two days; to Tombuctoo, fourteen; to the sea of Soudan, according to Jackson, fifteen; in all thirty-one: thus, we have Park's month; and the two statements coincide surprisingly.

Our readers are probably startled by the expression "country of the Christians." Jackson, however, makes a similar report. He says, "On its eastern bank (of the sea of Soudan) begins the territory of white people, denominated by the Arabs, (N'sarrath) Christians, or followers of Jesus of Nazareth." He adds some peculiarities of their dress and customs, and observes, that they are neither Arabs, Moors, Negroes, Shelluhs, nor Berebbers. Considerable light is thrown upon this subject by Hornemann, who, it appears, had heard much of a white and Christian nation as being in the vicinity of Soudan and Tombuctoo. He ridicules the idea of their being actually Christian; and states, that though the word *Nazari* has properly that signification, yet the Arabs familiarly give it to all who are not Mahometans. The nation in question he describes to be a branch of the Tuarick, called Tagama, who are white, (this term is probably comparative), and Pagans. (p. 110—19.) Upon Hornemann's *data*, Major Rennell has placed the Tagama Tuarick near the very point where Jackson places his Sea of Soudan. It is thus clear that there is, in this very quarter, a nation known in Africa by the term usually appropriated to Christians, which removes every fabulous appearance from the statements of Jackson and Park, and establishes a striking coincidence between them. *

Neither of these travellers mention any particular eye-witnesses; but their language implies, that they had met with such, and both allude to the existence of this inland sea, as a fact of complete certainty and notoriety. So grand and obvious a natural feature, which required only eyes to see it, seems to leave no room for mistake. Neither Park nor Jackson had the least idea of any coincidence between their respective statements, and still less with the Arabian writers; so that we have thus three independent testimonies from opposite quarters, meeting exactly in the same point. Nor does there, so far as we know, exist any evidence at all respectable to the contrary.

Applying then the existence of this lake to the question of the course of the Niger, we may observe, that every one who describes it, seems to labour for words to express its magnitude; which is farther manifested by its having been repeatedly mistaken for the ocean. If the sail of a hundred miles to Ulil, be supposed to give the breadth, this will equal it to the Caspian; even half that space will place it on a level with the Aral. These seas, though placed in a comparatively cold climate, where evaporation must be less active, receive, however, some of the greatest rivers of Europe and Asia. In the present instance, the power of evaporation must be extraordinary, as every account represents the heat to be intolerable, even to those who are accustomed to the burning sands of the Sahara. (*Afric. Assoc.* 1790, p. 124. *Cadamosto*, as above.) There seems, therefore, sufficient provision made for disposing, by evaporation, of the two great rivers, which, under the common name of Niger, seem to discharge themselves into this receptacle. †

The Course of the Gir of Ptolemy.

2. The river, to which Ptolemy has given the name of *Gir*, has not attracted the same attention among modern geographers, as among the ancient. Mr Pinkerton supposes it to be the Bahr Kulla of Browne, or the river, which, flowing from the westward, meets the Niger, and is lost in the same receptacle. On examining, however, the map, and descriptions of Ptolemy, we do not find that he considers these rivers as forming one line of stream, or even as communicating together; but as quite distinct, both in their source and termination. This circumstance, joined to their relative position, appears to leave no room for hesitation in adopting the opinion of D'Anville and Rennell, who identify the Gir with the river of Bornou. To this, we apprehend, must now be added the Misselad, which, from its relative course, must certainly communicate with the other. Mr Beaufoy's informants, indeed, clearly identify them, by stating the river of Bornou to rise from the same source *i. e.* vicinity ‡ with the Egyptian Nile. Major Rennell seems to sup-

* Mr Barnes, formerly quoted, states, that the Niger discharges itself into a large lake; that he has heard from the black traders, that there are *white* inhabitants upon the borders of this lake; and has been told by people who have seen them, that they dress in the style of Barbary Moors, and wear turbans (which agrees with Jackson, p. 262.) but do not speak Arabic. *Report of Committee of Council*, 1788.

† We have not included Ptolemy among our authorities, for reasons already stated; but it may be expected that we should prove that he advances nothing inconsistent with the above hypothesis. We observe, that the Lake of Lybia, which D'Anville and Rennell make the termination of the Niger, is not placed by Ptolemy upon the Niger at all, but upon one of its derivations or adjuncts, IV. 6. He gives nothing, therefore, which can be a termination, except the lake of Nigritia, to reach which it must flow westward. If this lake be supposed to be the Sea of Soudan, then the northern derivation, on which is placed Tuccaba (Tombuctoo ?) will be the Niger known to Europeans. We repeat, that we lay very little stress upon this interpretation; but if any thing can be made of Ptolemy, it seems to be this.

‡ Generally speaking, all rivers which arise in the same chain of mountains, are considered, in Africa, as having one source.

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pose that they run in different directions, and meet in the lake of Fittré. But the informants, both of Mr Beaufoy and Dr Seetzen, state distinctly that the river of Bornou flowed *from south to north;* to which the former added, that it was lost in the sands of the desert of Bilma. We have here the testimony of three respectable eye-witnesses, to which nothing stands opposed. The lake Fittré, besides, being in its permanent state only sixty or seventy miles in circumference (*Hornemann*), is ill fitted to be the receptacle of two such rivers. Considering then the whole as one, it will form a course from S. E. to N. W. of not much less than a thousand miles in direct distance. No portion of this mighty stream has ever been explored by any European; yet its course, and above all its termination, must be an object of great geographical curiosity. All that seems now ascertained, is, that, after traversing the empire of Bornou, it enters the vast desert of Bilma, out of which it never issues.

The Source of the Nile and its connection with the Niger.

3. With regard to the question whether the Niger and the Nile form a junction, Mr Hornemann mentions, that all the persons with whom he conversed, informed him, that the Niger flowed by Darfoor into the Nile, or Bahr-el-Abiad, and was, in fact, the same river: "he could not find a single person who said to the contrary." (p. 115—17.) Mr Jackson says still more pointedly: "In the interior of Africa, there is but one opinion as to the Nile of Egypt and the Nile of Tombuctoo, and that opinion is, that they are one and the same river." He adds, "The Africans express their astonishment whenever the Europeans dispute the connection of these two rivers." (p. 264.) Notwithstanding such positive assurances, it seems incontrovertibly proved by Major Rennell, that the opinion in question is totally erroneous. Herodotus, indeed, mentions it, but Ptolemy, whose information was greatly superior, clearly fixes the source of the Nile among the mountains of the Moon, in a direction nearly south from Egypt. The same information was received by Mr Browne, during his residence in Darfoor, at a few hundred miles from these sources. He learned also, that all the rivers, for a great distance southwards, flowed, not east towards the Nile, but quite in the opposite direction. What is still more important,—his route intersected the only line by which there was any likelihood of the Niger joining its waters to those of the Nile. A very little way south, the country begins to rise into the great chain of the Jibbel-el-Kumri, forming a complete barrier to the passage of a river which must previously have descended to the lowest level of the plain of Soudan.

But, although this point may be considered as settled, it remains still an interesting question, whether the two rivers may not communicate, by some intermediate channel, so as to form a continued navigation from Tombuctoo to Cairo. Mr Jackson positively asserts, that he knew a credible witness, who boasted of having actually performed this voyage. It is probable, that both the Misselad and the Kulla rise very near to the Nile, and afterwards communicate with the Niger; and it is possible, that at some point, particularly during the wet season, an union may take place. It is possible also, and perhaps more probable, that the two streams, like the Senegal and the Niger, may be considered as one, merely from approaching very near to each other. More precise testimony is necessary, in order to determine the question.

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In taking leave of these disputed points of African geography, we may observe, that the tract which extends southwards from the Mountains of the Moon, to the vicinity of the Cape of Good Hope, forms the greatest mass of *terra incognita* which now exists on the surface of the globe. Reckoning from the southern frontier of Darfoor and Abyssinia, we find an extent of nearly forty degrees, or two thousand four hundred miles in length, and nearly half that average breadth, which not only has not been visited by any European, but concerning which no detailed or authentic particulars have ever been received. Yet there is no reason to suppose, that it is either very thinly inhabited, or by people in the lowest stage of civilization. On the contrary, most of the limitary districts rank with the most civilized and populous portions of this continent. On the west are the kingdoms of Loango, Congo, and Angola; on the east are Monomotapa, Zanguebar, and the Somaulies. Even the heights of the Jibbel-el-Kumri are found, when crossed by the Ashantee Caravan, to abound in cattle, provisions, and people. The immediate vicinity of the Cape is barren and savage; but, in proportion as we advance northward, an improvement takes place. The tribes of Boshuanas recently visited, and still more those lying more remote, hold a high rank among the nations of Africa. Doubtless, there are deserts here also, and particularly a very extensive one, reaching north from the Orange river. But there appears no probability that they should bear any proportion to those which exist on the northern side of the continent.

Miscellaneous Particulars.

VI. We shall conclude this article, with some miscellaneous details, regarding the present state and future prospects of this quarter of the globe. There is scarcely any question involved in greater uncertainty than the extent of its *Population*. The few estimates which have been attempted are founded chiefly on random conjecture, and exhibit an extraordinary discrepancy of results. M. Golberry, who seems to have particularly attended to this subject, hesitates not to carry the amount to one hundred and sixty millions. (*Voyage en Afrique.*) Mr Beaufoy seems to have entertained nearly the same idea, as he estimates the interior at a hundred millions. (*African Assoc.* 1790.) Mr Pinkerton, on the other hand, does not conceive that it can exceed thirty, perhaps not twenty millions. M. Malte Brun names seventy millions as the utmost conceivable limit. (*Precis de la Geographie*, II. 560).

Population.

The only principle on which any thing like an approximation can be founded seems to be this,—that the state of industry and civilization throughout cultivated Africa is so nearly the same, that the ratio of the ascertained density of any one portion may be extended to the whole. Golberry has

* *Af. Assoc.* 1790, 138—42. *Malte-Brun, Annales*, XIX. 168.

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formed a calculation, apparently pretty correct, by which he makes the square surface of Africa to amount to one million six hundred thousand square leagues, of twenty-five to a degree, which is equal to upwards of nine millions of square geographical miles. These, at a moderate European rate, would give a population of four or five hundred millions. There are many circumstances, however, which must materially reduce the African standard. The most prominent is the immense extent of its deserts. The Sahara, with all its adjuncts, equals perhaps the whole of Europe. Its *Oases*, even the larger ones of Fezzan and Darfoor, though they relieve the aspect of sterility, do not materially change its general character. The former is calculated to contain only seventy-five thousand souls, the latter two hundred thousand; which will not exceed four or five to the square mile. Even the most fertile regions of Barbary and Nigritia are deeply indented with desert. We cannot, therefore, consider as exaggerated the estimate of Mr Pinkerton, that a full third of its extent is of this description. Of the remaining six millions, we think we may allow a third for those savage tracks, which, being devoid of cultivation, do not materially affect the general populousness of the continent. There will then remain four millions of square miles for cultivated Africa.

Mr Penny, a trader, who was intimately acquainted with every part of the African coast, being asked, in the Committee of Council (*Report on Africa and the Slave Trade*, 1788,) his ideas upon its populousness, answered as follows: He thought every one who had visited Africa and America must have been struck with the appearance of nearly an equal population on the coast of Guinea, and in the State of Virginia. Virginia contained then eight hundred thousand inhabitants, upon thirty thousand square miles, which is $26\frac{2}{3}$ to the square mile.

M. Golberry is the only African traveller who has furnished any precise *data* upon this head. In the course of his work, he gives the population of a number of states upon the Gambia and Senegal, as ascertained by the French colonial administration; and we shall throw the results into the following table:

| *Districts.* | *Vol. p.* | *Sq. Leagues.* | *Inhabitants.* |
|---|---|---|---|
| Cayor, | II. 102 | 2000 | 180,000 |
| Sin, | II. 109 | 140 | 60,000 |
| Salum, | II. 112 | 1500 | 300,000 |
| Barra, | II. 158 | 252 | 200,000 |
| Bambouk, | I. 432 | 1000 | 60,000 |
| | | 4892 | 800,000 |

This gives 163 to the square league, or $26\frac{1}{2}$ to the square mile;—a result, the coincidence of which with the estimate of Mr Penny, is somewhat remarkable. Probably, therefore, we may not err very widely in fixing this as the average amount of population along the coast of Guinea, nor even in extending it to the whole of cultivated Africa. If some districts fall short of this standard, there are others of considerable extent,—as Egypt, Houssa, Tombuctoo, Whydah,—which must greatly exceed it. Four millions, then, of square miles, at the above rate, would give a population of a hundred and six millions; to which some addition must be made, though it would be difficult even to form a guess as to its amount, for the more desert and savage districts.

Commerce.

The *Commerce* of Africa has always presented some peculiar features. The first and most prominent is the immense scale of *land conveyance*. Africa is perforated by no arms of the sea; and her rivers, though large, are imperfectly navigable, and do not flow in a convenient direction. It is by land chiefly that the merchant must find his means of exchange; and his route must lie, not on smooth roads through smiling countries, but over an immeasurable expanse of trackless desert, where whirlwinds of sand threaten to overwhelm him at every step. To guard against these dangers, as well as to enliven the dreary scene, merchants were naturally led to form themselves into companies, which are known under the appellation of Caravans. The camel, an animal which nature seems to have formed expressly for travelling through the desert, is universally employed. The rate of progress is three miles an hour, and seldom more than seven or eight hours in the day. At each of the *oases*, a stay of at least two days is made, for the purpose of obtaining fresh supplies of water and provisions. The following are some of the principal routes pursued by these caravans: 1. From Mourzouk, the capital of Fezzan, to Cairo; a route of about forty days. The halting places are Siwah, Augila, and Temissa. 2. From Mourzouk to Bornou; a journey of fifty days. The track is through the deserts of Bilma and Tibesti; and the principal halts are at Temissa, Domboo, and Kanem. 3. From Mourzouk to Cashna. This occupies sixty days, through Hiatts, Ganatt, and Agades. 4. From Fez to Tombuctoo, a journey of fifty-four days; but as sixty-five besides are spent in rest, the whole number of days required is one hundred and twenty-nine. The stations are Akka or Tatta, the general rendezvous; Tegazza, and Arawan, or Aroan. Another route, along the sea-coast, leads to the same point by Wedinoon, Cape Bojador, and Gualata. 5. and 6. The caravans from Sennaar and Darfoor to Egypt. These do not travel so regularly as the others; and an interval of two or three years often elapses. The caravan with which Mr Browne travelled consisted of five hundred camels; but the number often reaches two thousand.

Caravan Routes.

Slaves.

With regard to the objects of trade, and particularly of export, these have presented a remarkable similarity, in all ages, and over every part of this continent. The first, and by far the most considerable, has always unhappily been the trade in the human species. Africa has in all ages been ransacked for those unfortunate beings, whose degradation was to be the instrument of pleasure or avarice to the lords of the other portions of the globe. Besides the European part of this atrocious traffic, (ere long, it is to be hoped, to be fully, and for ever relinquished,) there has long been a similar trade for the supply of Barbary and some countries of the East.* The vic-

* The history and actual state of the trade in slaves, for European purposes, will be given under the head SLAVE TRADE in this Supplement.

Africa. tims are drawn chiefly from the barbarous tribes inhabiting the central range of mountains. The whole number for this supply is estimated at twenty thousand. Part of these captives undergo a shameful mutilation, with the view of being placed in the seraglios of the East. In other respects, their lot is much milder than that of their West Indian brethren. They are used as domestics, are well treated, and often raised to posts of distinction.

Gold. Next to the human species, the article of exchange which Africa produces most abundantly, is gold. It seems probable that its mountains contain mines of this coveted metal, more ample even than those of the new world. All the rivers which descend from the Jibbel-el-Kumri, on both sides, and throughout its whole extent, roll down sands of gold. The great repositories are Wangara, the country near the sources of the Senegal and Niger, and that immediately behind the Gold Coast. Its abundance in the districts along the Niger is said almost to surpass conception. Mr Jackson states, we suspect with exaggeration, that at Tombuctoo, it is often exchanged for its weight in salt, tobacco, or other valuable commodities, (p. 260.) About the beginning of the present century, the value of that exported from the gold coast, is said to have amounted to between two and three hundred thousand pounds. (*Wadstrom on Colonization.*) We have not been able to obtain precise information respecting the present state of this trade; for the prejudices of the mercantile system prevent gold from being classed with other commodities in the amount of exports and imports. The slave captains in their examinations before the Committee of Council, (1788) generally state, that it was too costly to be an object of trade; that it sold at L.4. an ounce, and that they did not find it their interest to procure it, unless as a medium for the purchase of slaves. They admit, however, that the Dutch exported it; and the truth seems merely to be, that they found the other trade more profitable.

Ivory. Next to gold, ivory has always been the great subject of African export. Like gold, it is produced almost solely in the interior, and thence brought down to the coast. Where those vast meadows lie which feed such herds of elephants, has never been ascertained; but Europe derives from Africa its whole supply of this valuable article.

Gum. Gum, particularly *Gum Senegal*, forms an important branch of trade. The southern parts of the desert of Sahara contain vast forests of that species of *acacia*, from which this substance exudes. In the month of December, a dry and piercing wind bursts the bark, and the juice flows out. The neighbouring Moorish tribes then leave their habitations, and employ themselves for six weeks in collecting it; after which they repair to the banks of the Senegal, to exchange it for European commodities. The price is first fixed by a meeting of the merchants with their kings and chiefs. This point being settled, in a few days the Moors appear in vast bands, with their wives, children, and cattle; and for some days, a tumultuous market is held. M. Golberry calculates, that two millions of pounds of gum may be drawn from this part of Africa. (*Travels*, chap. vi.)

Among the valuable productions of this country, we may also mention hides and skins, particularly goats skins dyed red or yellow. These are brought by the caravans from central Africa to Morocco, whence they are exported to Europe, chiefly from the port of Mogador. Africa exports likewise ornamental and dye woods, particularly red or cam wood, to a very considerable extent. Raw hides and bees wax have, within the last few years, become considerable articles.

There are doubtless many other minor and local objects; but those now enumerated may be considered as forming the basis of African export. It is remarkable that, with the exception of a small quantity of leather, the whole consists, not merely of the unmanufactured, but of the spontaneous produce of the land. So small is the progress yet made by cultivation throughout this great continent. The imports are limited, by the limited wants of the climate and state of society. The manufactures most in demand are checked cottons, light coarse cloths, red woollen caps, a few linens and silks, and a large proportion of India piece-goods. Spirits, chiefly rum, are too much in demand; guns and gunpowder, hardware, chiefly in the form of knives, sabres, blades; brass, which is manufactured into ear-rings; coral, beads, looking-glasses, and other articles of ornament. The scarcity of salt causes a certain import from Britain, even of that bulky article.

The following tables are made up from information laid before the House of Commons, 13th June 1812:

IMPORTS.

| ARTICLES. | 1805. | 1806. | 1807. | 1808. | 1809. | 1810. |
|---|---|---|---|---|---|---|
| | L. | L. | L. | L. | L. | L. |
| Elephants' Teeth . . . | 10,285 | 11,331 | 10,693 | 14,314 | 16,270 | 16,488 |
| Gum Arabic . . . . . | 3,947 | 4,190 | 4,333 | 6,203 | 3,536 | 8,420 |
| —— Senegal . . . . | 16,223 | 17,797 | 14,455 | 12,270 | 21,550 | 46,384 |
| Hides, raw and tanned . | 1,257 | 990 | 2,472 | 2,308 | 4,143 | 12,714 |
| Skins and Furs . . . . | 10,853 | 8,318 | 34,124 | 36,401 | 23,800 | 76,437 |
| Wax, Bees . . . . . | 2,009 | 3,436 | 8,297 | 13,817 | 20,436 | 12,996 |
| Red Wood . . . . . | 51,311 | 52,160 | 27,753 | 15,908 | 47,791 | 26,058 |
| All other articles . . . | 10,960 | 17,926 | 19,921 | 42,055 | 47,125 | 57,790 |
| Official value . . . . | 106,845 | 115,948 | 122,948 | 143,276 | 184,651 | 257,387 |
| Real Value . . . . | 193,034 | 226,396 | 242,747 | 374,306 | 383,926 | 535,577 |

Africa.

## EXPORTS.

| ARTICLES. | 1805. | 1806. | 1807. | 1808. | 1809. | 1810. |
|---|---|---|---|---|---|---|
| | L. | L. | L. | L. | L. | L. |
| Brass and Copper . . . | 12,085 | 10,315 | 6,496 | 6,979 | 3,755 | 3,231 |
| Cotton Manufactures . . | 285,408 | 456,661 | 303,106 | 168,310 | 305,632 | 196,214 |
| Gunpowder . . . . . | 27,154 | 38,179 | 21,022 | 6,567 | 8,453 | 7,887 |
| Guns . . . . . . . . | 48,500 | 57,685 | 35,698 | 7,452 | 14,251 | 6,393 |
| Iron and Steel . . . . | 17,703 | 44,464 | 26,870 | 28,721 | 30,302 | 19,139 |
| Woollens . . . . . . . | 78,394 | 124,510 | 58,788 | 51,955 | 76,430 | 68,402 |
| India Piece Goods . . . | 324,087 | 390,605 | 175,963 | 72,444 | 84,472 | 59,967 |
| Brandy and Geneva . . | 8,490 | 38,109 | 15,853 | 5,453 | 7,499 | 1,722 |
| Rum . . . . . . . . | 56,181 | 43,855 | 10,636 | 12,066 | 11,663 | 7,551 |
| All other articles . . . | 132,573 | 228,769 | 143,308 | 172,894 | 163,522 | 113,579 |
| Official value . . . . | 990,575 | 1,433,152 | 797,740 | 532,841 | 705,979 | 484,082 |
| Real value . . . . . | 1,156,985 | 1,655,042 | 1,022,745 | 820,194 | 976,872 | 693,911 |

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On the best mode of exploring Africa.

On adverting to the future prospects of Africa, it is proper to say something, in the first place, as to the means of its more perfect exploration. It seems, then, to be now universally admitted, that no reliance can be placed on the common plan of solitary enterprize, or where the traveller has only one or two attendants. Nor is the device of assuming the character of a Mahometan likely to be repeated. Mahometanism is not a mere creed; it is a system, which regulates the whole train of thoughts and habits, and which moulds from infancy even the outward aspect and deportment. It is vain to expect, that the study of Arabic at an European seminary, or even a few months residence in the East, could mould all the habits of an European into a shape, which would enable him to deceive the watchful eyes of Musulmen. It appears also, that, while the character of a professed Christian is sufficiently detested, that of one who assumes a false semblance of Mahometanism is viewed with a much higher degree of reprobation. To the disguise, therefore, which Hornemann assumed, it is probable that this unfortunate traveller was partly indebted for his melancholy fate. The only mode, then, it would appear, of penetrating into Africa, with any prospect of success, is to carry an armed force, which shall not be so large as to excite alarm, and yet sufficient to guard against desultory or sudden attack. Such an expedition would the less tend to excite jealousy, that Africa is habitually traversed by parties of this description for commercial purposes. Yet it is remarkable, that the two attempts which have been made upon this plan have terminated still more fatally than those in which no such precautions had been taken;—we allude to the last expedition of Park, and that sent by Lord Caledon from the Cape of Good Hope. These failures, however, we regret to say, seem to have been the result of such obvious imprudence, as not to authorize any inference against the general superiority of this plan. Park, by unluckily exposing his party to be destroyed by the rainy season, reduced himself to the same unprotected state with former travellers. The expedition from the Cape was too small; and yet, till they gave way to supine security, and sacrificed all the advantages of their strength by dividing it, no hostile attempt appears to have been made.

The editor of Park's last journal recommends an expedition on a large scale, to be composed chiefly of African soldiers enlisted at Sierra Leone; but we cannot help feeling some doubts as to the safety of an expedition, in which the majority should be Africans. And as this writer suggests the propriety of employing a traveller from the East, we would add, that his attendants should rather be *Seapoys* than Africans.

Means of Civilizing Africa.

The plan upon which the main reliance for the civilization of this region seems at present to be placed is, that of an extensive system of colonization. It is observed by Mr Macaulay, Ex-secretary of the African Institution, that it is "necessary to the *rapid* growth of improvement, that men should be brought to live together in considerable bodies; that they should be protected by just laws; and that they should enjoy the means of instruction." This, he conceives, can only be effected in Africa by means of a colony, of some extent, composed of natives. The difficulty of collecting a large native population is admitted, indeed, to be very great. The Africans, from many causes, and particularly from superstition, will not *voluntarily* resort to such a colony. A plan had, therefore, been suggested, in reference to the co-

* These tables exhibit a curious view of the effects of the abolition. Almost all the articles of import have remarkably increased, and their general amount has more than doubled. The exports have necessarily suffered a considerable reduction, which, however, has taken place almost wholly in the articles of guns, spirits, and (we know not exactly why,) of India piece-goods; while British manufactures maintain nearly their former amount.

lony of Sierra Leone, to redeem the Grumettas, or native slaves, and transplant them to that establishment; but this plan was, after mature deliberation, and apparently upon very solid grounds, rejected. Even though some unexceptionable mode of collecting a mass of native population could be devised, we greatly suspect, that it would, in the end, be found still more difficult, if not impossible, to prevent those evils and abuses, which seem almost inseparable from the management of these distant establishments; and perhaps the friends of Africa would act more wisely, in limiting their views to coast settlements, solely for the purposes of opening and maintaining a ready communication with the natives. For our own parts, we are inclined to think, that if any thing farther ought to be attempted, the growth of civilization in Africa is more likely to be accelerated by calling to our aid the agency of their own chiefs, than by any attempts at extended colonization. We believe it to be conformable to the tenor of history, that some species of *compulsion* is necessary to the *speedy* civilization of barbarians; and that it is only in this way that their inveterate habits of sloth and indolence can be overcome. *Conquest*, therefore, has hitherto been the chief means of spreading civilization. The only kind of *compulsion* applicable with this view to Africa, is that which might be exercised by her native sovereigns. It was thus that the career of civilization was begun in Russia, and it is in this way that the Sandwich Islands are now civilizing. Our plan then would be, to invite some African chiefs to Europe, not to learn to read and write, but to show them the value of those branches of art, and means of opulence, the transplantation of which would render their own power more extensive, and more brilliant. Were an ambition of this kind once kindled in one or two active chiefs, *their* authority would soon, it is probable, effect a decisive change among their listless countrymen. But in order to give success to such a plan, all fear of conquest, or interference on our part, must be removed; and the ablest, most powerful, and also the most *absolute* chiefs, must be courted and employed, as the properest instruments for effecting such a revolution. (B.)



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AFRICAN ASSOCIATION. See ASSOCIATION, AFRICAN, in the Encyclopædia.

AFRICAN COMPANY. The reader will find, under the head COMPANY, in the body of the Work, an account of the formation of this establishment, and the footing on which it at present stands. Though instituted for commercial purposes, it is now prohibited from trading in its corporate capacity; and its functions are limited to maintaining the forts on the Gold Coast; a sum for that purpose being annually allowed by Government. In the Report of the Commissioners appointed to inquire into the state of the African Settlements, in 1812, the following is stated to be the annual expence of each of these forts:

| | | | |
|---|---|---|---|
| Appolonia . . . . . L. | 879 | 7 | 10½ |
| Dixcove . . . . . . | 926 | 2 | 5 |
| Succondee . . . . . . | 429 | 3 | 5½ |
| Commenda . . . . . | 842 | 2 | 3½ |
| Cape Coast Castle . . . | 4,768 | 9 | 1¼ |
| Annamaboe . . . . . | 1,885 | 12 | 3¼ |
| Tantumquery . . . . | 771 | 17 | 6¾ |
| Winnebah . . . . . | 776 | 8 | 11 |
| Accra . . . . . . . . | 1,328 | 1 | 0 |
| Whydah . . . . . . | 587 | 16 | 6¾ |
| | L. 13,195 | 1 | 5¾ |

The whole annual expences of the Company in Africa, for forts, salaries of officers, &c. is stated to be L. 25,327, 1s. 5¾d.

It further appears from this Report, that the trade of the coast is chiefly in the hands of the Governors of the forts, to each of whom it affords a perquisite of from L. 800 to L. 1000 a year. Their local knowledge and influence give them an advantage, with which ships coming from a distance cannot compete. Cape Coast forms the only exception, as there are several European agents residing there. The number of forts appeared to the Committee to be much greater than is necessary for maintaining the British influence upon this coast; and in consequence, Winnebah and Whydah were abandoned, which has so far reduced the annual expence.

The Company were recently called upon to explain the reason of their sending out goods, which did not appear necessary for the use of their settlements. To this they answered, that the act 23 Geo. II. ch. 31. by which they were constituted, expressly authorizes them to make their African payments in goods; that the remittance of the salaries of their servants in any other form would be attended with great inconvenience, both to the Company and to individuals; and that the profit made upon these goods enables the Company, with an annual grant of L. 23,000, to support an expenditure in Africa of L. 25,000, and to defray the expences of management at home.

The Company's charges at home, consist of L. 100 to each of the nine members of the committee; and L. 300 to the secretary; in all L. 1200. The number of persons in their employ, at Christmas 1813, consisted of 47 Governors and subordinate officers; 450 soldiers and menials; and they had thirty seven Negro chiefs in their pay. (B.)

AFRICAN INSTITUTION. This Institution was formed in 1807, for purposes which, to use the words of a celebrated Literary Journal, "certainly render it one of the most interesting, and most creditable to the feelings and character of our country, that ever found support within its bounds." (*Edinb. Review*, Vol. XV. p. 485.) Its general objects, and the views which influenced its formation, are clearly stated in the following resolutions adopted, at the constituent meeting, held on the 14th of April 1807.

"1. That this meeting is deeply impressed with a sense of the enormous wrongs which the natives of

PLATE XV.


NORTHERN & CENTRAL
AFRICA
NORTH ATLANTIC OCEAN
SOUTH ATLANTIC OCEAN
MEDITERRANEAN SEA
SPAIN
PORTUGAL
Madrid
Lisbon
Corsica
Sardinia
Sicily
ITALY
TURKEY
Candia
Jerusalem
ARABIA
Persian Gulf
Madeira I.
Canary Is.
Azores
Algier
Tunis
Tripoli
Alexandria
Cairo
Suez
Thebes
Sennaar
Mocha
Berbera
Tombuctoo
Houssa
Sea of Soudan
Cassina
Daura
Bornou
Kanem
Darfur
Kordofan
Abyssinia
Gondar
Fezzan
Mourzouk
Gualata
Wadelims
Mongearts
Labdessebas
Foulahs
Jaloffs
Feloops
Bambara
Kaarta
Kong
Benin
Waree
Biafra
Calbongas
Gabon
Gobbi
Camma
Loango
Congo
St Salvador
Angola
Anziko
Pombo
Ambous
Dahomey
Ashantee
Apollonia
Ivory Coast
Gold Coast
Equator
MOUNTAINS OF KONG
Jibbel Kumri
UNKNOWN TERRITORY
AZANIA
SOMAULI
Mombasa
Zanzibar
SOUDAN OR NIGRITIA
SAHARA or GREAT DESERT
LIBYAN DESERT
TUARICK
Nubian Desert
Bahar el Abiad or White R.
Mr Parks 1st Rout Thus
2d Do Thus
15 Longitude West 10 from Greenwich 5
30 Longitude East 35 from Greenwich 40

Africa have suffered in their intercourse with Europe; and, from a desire to repair those wrongs, as well as from general feelings of benevolence, is anxious to adopt such measures as are best calculated to promote their civilization and happiness.

"2. That the approaching cessation of the slave trade, hitherto carried on by Great Britain, America, and Denmark, will, in a considerable degree, remove the barrier which has so long obstructed the natural course of social improvement in Africa; and that the way will be thereby opened for introducing the comforts and arts of a more civilized state of society.

"3. That the happiest effects may be reasonably anticipated from diffusing useful knowledge, and exciting industry among the inhabitants of Africa, and from obtaining and circulating throughout this country more ample and authentic information concerning the agricultural and commercial faculties of that vast continent; and that through the judicious prosecution of these benevolent endeavours, we may ultimately look forward to the establishment, in the room of that traffic by which Africa has been so long degraded, of a legitimate and far more extended commerce, beneficial alike to the natives of Africa and to the manufacturers of Great Britain and Ireland." (*First Report*, p. 2.)

The particular means which this society proposes to employ for promoting civilization and improvement in Africa, are of the following kind:

"1. To collect and diffuse, throughout this country, accurate information respecting the natural productions of Africa, and, in general, respecting the agricultural and commercial capacities of the African Continent, and the intellectual, moral, and political condition of its inhabitants.

"2. To promote the instruction of the Africans in letters and in useful knowledge, and to cultivate a friendly connection with the natives of that continent.

"3. To endeavour to enlighten the minds of the Africans with respect to their true interests; and to diffuse information amongst them respecting the means whereby they may improve the present opportunity of substituting a beneficial commerce in place of the slave trade.

"4. To introduce amongst them such of the improvements and useful arts of Europe as are suited to their condition.

"5. To promote the cultivation of the African soil, not only by exciting and directing the industry of the natives, but by furnishing, where it may appear advantageous to do so, useful seeds and plants, and implements of husbandry.

"6. To introduce amongst the inhabitants beneficial medical discoveries.

"7. To obtain a knowledge of the principal languages of Africa, and, as has already been found to be practicable, to reduce them to writing, with a view to facilitate the diffusion of information among the natives of that country.

"8. To employ suitable agents, and to establish correspondences as shall appear advisable, and to encourage and reward individual enterprize and exertion in promoting any of the purposes of the institution." (*First Report*, p. 4.)



The management of the affairs of this institution is vested in a patron and president, twenty vice-presidents, a treasurer, and a board of thirty-six directors. These officers are chosen annually from among that class of the subscribers who are called *governors* of the institution. Those who subscribe sixty guineas at one time become hereditary governors; but thirty guineas subscribed at one time, make the subscriber a governor for life; or three guineas annually, a governor during the continuance of this annual subscription. Every subscriber of one guinea becomes an ordinary member, and continues so during the continuance of his subscription.

It is much to be regretted, that the funds of this noble institution are far too limited to enable it to pursue with vigour those great objects which it was intended to promote. Its *annual* income does not exceed L. 400; and, including donations, its whole receipts, of every kind, from its first formation to the commencement of the present year (1815), have amounted to only L. 9850. With such scanty means, it is impossible to do much in a *direct* way towards the advancement of civilization. A single fact will suffice to shew this. To a male and female teacher lately sent to Sierra Leone, the society allows a salary of L. 300 a-year, and this sum, moderate as it is, exhausts three-fourths of its annual income. But though the Institution has not hitherto been enabled to commence any extended plans of civilization in Africa, it has happily been able to aid materially in paving the way for such plans, by exerting its influence to effect a thorough abolition of the slave trade. This is the first great and indispensable step towards the improvement of Africa; and the vigilant attention of the society to this primary object has been of the greatest importance, both by enforcing a rigorous execution of the abolition laws enacted in this country, and by animating and directing the public call upon other nations to follow our example.

The proceedings of the society are fully detailed in its annual Reports, which are regularly published. These Reports are written with great ability, and contain much valuable and interesting information in regard to Africa, and the means of civilizing it. It may be proper to add, that the conduct of the directors has been severely attacked, and their Reports criticised, in a pamphlet lately published by Dr Thorpe, who, for sometime, held the office of Chief Judge in the colony of Sierra Leone. The directors have replied to his accusations with great temper, and, in so far as we can judge, with complete success, in a *Special Report*, read at a general meeting in April last (1815), and since published.

AGNESI (Maria Gaetana), an Italian lady, who may be justly pronounced one of the greatest wonders and ornaments of her sex, was born at Milan on the 16th of May 1718. Our materials for an account of this celebrated female are by no means so complete, nor in some interesting particulars so distinct, as we could have wished. Not having been

Agnesi.

able to procure her Eloge by *Frisi*,* we have been obliged to content ourselves with some shorter notices; the most detailed of which is that contained in Mazzuchelli's *History of the Writers of Italy*, a work published during the earlier, but more brilliant period of her life. The accounts which this writer and some others have given of the intellectual capacities and endowments which she displayed in early youth, call to mind the wonders which have been related of Picus of Mirandula, and the Admirable Crichton. Nor does there seem any reason to doubt their authenticity. At nine years of age, she not only spoke the Latin language with precision, but even composed and delivered an oration in that language, intended to prove that the cultivation of letters is not incompatible with the female character. This singular piece was published at Milan the same year in which it was spoken, with the following title: *Oratio qua ostenditur artium liberalium studia a fœmineo sexu neutiquam abhorrere, habita a Maria de Agnesiis rhetoricæ operam dante anno ætatis suæ nono nondum exacto, die* 18 *Augusti* 1727.

At eleven years of age, she spoke Greek with all the fluency of her native tongue. When yet very young, she had also acquired some of the languages of the East; and, in a word, her acquisitions as a linguist were such, as to procure for her the appellation of a *Walking Polyglott*. But her aptitude for acquiring languages, however great, was by no means the only, or the most striking feature of her intellectual character. We have seen how early she essayed the discussion of a general question affecting the mental capacities of her sex, and the vigour and acuteness displayed in this aspiring essay were, ere long, exerted with ardour and success in scientific inquiries. Having gone through the elementary branches of mathematics, she proceeded with alacrity to the study of natural philosophy; and she seems also to have carried her researches into the obscurer regions of metaphysical speculation.

About the time when she reached her fifteenth year, her father formed a select assembly of the learned of Milan, and at these meetings, which were held in his house, at stated times, for several years, Agnesi maintained a succession of *Theses* on various points of speculation and philosophy. The ability which she displayed on these occasions seems to have been altogether surprising; and the effect was not the less, that her person was agreeable, and her whole deportment gentle and prepossessing. We are indebted to the learned President De Brosse for the following account of one of these conferences, at which he assisted during his travels in Italy, through the introduction of Count Belloni. "I had conceived," says he, "when I went to this *conversatione*, that it was only to talk with this young lady in the usual way, though on learned subjects; but to my surprise, Belloni addressed her in a fine Latin harangue, with all the formality of an academic oration. She replied in the same language, with promptness and ability; and they proceeded, still in Latin, to discuss the origin of fountains, and the causes of the ebbings and flowings observed in some of them. She spoke like an angel on this subject, and I never heard it treated so much to my satisfaction. We then discoursed with her concerning the manner in which the soul receives impressions from outward objects, and their conveyance to the general *sensorium*, the brain; and afterwards upon the propagation of light, and the prismatic colours. The conversation afterwards became general, every one speaking to her in the language of his own country, and she answering in the same." (*Lettres sur l'Italie*, Tom. I. p. 243.) But Agnesi seems to have taken but little delight in the glory which she acquired as a philosophical disputant. Her temper was retired and devout, and she appears to have acted this part more to gratify her father than herself. About her twentieth year, she accordingly withdrew from these assemblies, and for a long period devoted the greater part of her time to mathematical studies. The Theses which she had maintained with so much applause were published in a quarto volume, under the following title: *Propositiones Philosophicæ quas crebris disputationibus domi habitis coram clarissimis viris explicabit extempore et ab objectis vindicabat Maria Gaetana de Agnesiis Mediolanensis.* Med. 1738.

The first fruit of her mathematical studies was a Commentary on the *Conic Sections* of the Marquis de l'Hospital; but this piece she would never consent to publish, though Mazzuchelli says that it was greatly praised by many who had perused the manuscript. In the course of a few years, however, she gave to the world a mathematical work, which must ever secure her a high rank among the most distinguished cultivators of abstract science. This work, entitled *Instituzioni Analitiche ad uso della Gioventu Italiana*, was published at Milan in 1748, in two volumes quarto. The first volume treats of the analysis of finite quantities; the second, of the analysis of infinitesimals. These two volumes contain a full and satisfactory view of this branch of mathematical science in the state at which it had then arrived; and though improvements have since that time been introduced, the treatise of Agnesi, according to a very competent authority, may still be regarded as perhaps the best introduction that is to be found to the works of Euler, and the other mathematicians of the Continent. (*Edinb. Review*, Vol. III. p. 408.)—An English translation of this work was long ago executed by the late Professor Colson of Cambridge, but the manuscript lay buried in obscurity for many years, and was only published in 1801, through the care and at the expence of Baron Maseres.

Besides other literary honours which followed the publication of the *Analytical Institutions*, Agnesi was, in 1750, appointed Professor of Mathematics and Natural Philosophy in the university of Bologna. The appointment of a young female, of thirty-two years of age, to such a charge, must appear to many

* This Eloge has been translated into French by Boulard, and published both separately, and at the end of a work entitled, *Bienfaits de la Réligion Chrétienne*, 2 vols. 8vo, 1807. See *Biographie Universelle*, Tom. I.

Agnesi || Agriculture.

as not a little singular; but the truth is, that female professors were by no means uncommon in Italy; and La Lande mentions several as having been eminent in the same university, one of whom was Professor of anatomy. (*Voyage en Italie*, Tom. II.) Our scanty information does not enable us to state whether Agnesi ever entered upon the active duties of the mathematical chair. Though her life was long, we can add but little in regard to her after-history. She died, according to the meagre notice contained in the *Biographie Universelle*, in the year 1799. Her mistaken notions of religious duty rendered the greater part of her existence but a blank to the world. She had early expressed a wish to retire into a convent, and seems to have carried this design into effect not long after the period when her great work procured for her the honours to which we have just alluded. We afterwards hear of her only as a devoted sister of the austere order of *Blue Nuns*, repelling the approaches of those of the learned who still desired to converse with her, and thus exhibiting another melancholy instance of the inconsistencies of our nature, and the darkening power of superstition over the brightest minds. But she lived long enough for the world to vindicate the intellectual capacities of her sex,—to show that the female mind is not only fitted for the lighter exercises of literature, but capable also of fathoming the depths, and unravelling the intricacies of abstract science. If there are any, therefore, whose speculations may have led them to more depreciating conclusions, let them, to use the words of a profound and eloquent writer already quoted in this article, "peruse the long series of demonstrations which the author of the *Analytical Institutions* has contrived with so much skill, and explained with such elegance and perspicuity; if they are able to do so, they will probably retract their former opinions; if unable, they will not of course see the reasons for admiring her genius that others do; but they may at least learn to think modestly of their own." (*Edinb. Rev.* Vol. III. p. 410.)

# AGRICULTURE.

Objects of this Article.

THE subject of this article has been so largely treated in the body of the work, that it would be equally improper and unnecessary to attempt any thing like a complete or formal treatise in this place. But as the view of agriculture there given, belongs to a time when the change from what is called the old to the new husbandry, had not yet been completed in any part of Britain; and as the progress of improvement has, of late years, been rapid and extensive beyond all former experience; it hence becomes necessary that we should here exhibit a more particular account of that important change, and of the present state of knowledge in general, in regard to the principles and practice of this, the most important of the economical arts. In doing so, it shall be our endeavour to avoid repetition; and when we touch upon any ground already examined by our predecessors, it shall only be for the purpose of adding more correct, or more useful information.

Its arrangement.

Such being the objects of this supplementary article, we hope to be able to accomplish them, by the details and observations which we shall offer under the four following chapters. In the *first*, we shall treat of what regards the cultivation and products of ARABLE LAND; in the *second*, of the management of GRASS LANDS, and the improvement of WASTES; in the *third*, of agricultural LIVE STOCK; and in the *fourth*, which will be of a more general kind, we shall endeavour to point out those circumstances which have more particularly contributed to the improvement of agriculture in this country, and those also which seem still to obstruct its further advancement.

Parts of the subject referred to other heads

There are, besides the subjects which fall to be treated under these divisions, some others, which certainly form component parts of agricultural science, and to which it will be necessary to advert in this work; but as these subjects are not of equal interest to husbandmen generally, and as they are capable of being treated with advantage in a separate form, we shall reserve them for distinct articles, to be afterwards introduced under their respective heads. Such are the subjects of the DAIRY, of DRAINAGE, of EMBANKMENT, of IRRIGATION, and of WOODS or PLANTATIONS.

## CHAP. I.

## ARABLE LAND.

We shall endeavour to arrange all the most important details connected with this first division of our subject under the eight following sections: 1. Of implements and machinery: 2. Of farm-buildings: 3. Of fences: 4. Of tillage: 5. Of fallowing: 6. Of the cultivation of the different crops: 7. Of the order of their succession: 8. Of the various substances used as manure, and the modes of applying them.*

* We have not thought it necessary to make *Soils* the subject of a separate section under this chapter, because the article in the body of the work contains nearly all that can be said in regard to them, in a popular way. Those who wish to go further may consult the *Elements of Agricultural Chemistry*, by Sir Humphry Davy, whose observations we could not have abridged with any advantage in this place.

Implements

## Sect. I. Implements and Machinery.

Implements for different purposes.

The numerous implements of tillage husbandry may be arranged under these six heads;—such as are employed, 1. In preparing land for semination; 2. In depositing the seed; 3. During the growth of the plants; 4. In reaping and securing the crop; 5. In preparing it for market; and, 6. In the general purposes of a farm. But as the same implement is sometimes used for more than one purpose, it would be of little consequence to adhere strictly to this or any other arrangement. The implements required for rendering land fit for tillage do not belong to this part of the article, and several others that have not yet been brought into general use, or are employed only for particular purposes, shall be noticed under the sections to which they respectively belong.

### 1. *Ploughs.*

Great diversity of form.

Of ploughs there are a great many different sorts; and, besides the variety of construction occasioned by the difference of soils, and the different purposes for which they are employed even on the same soil, there is a considerable diversity in the form, in districts where both the soil and the mode of culture are nearly alike. The most obvious general distinction among ploughs is, their being constructed with or without wheels; and each of these kinds may be again distinguished by other circumstances;—such as the form of the mould-board and share; their operation in making one or more furrows at a time; their size; and the depth at which they are calculated to work, as in trench-ploughing. It would neither be of much utility, nor at all consistent with our limits, to describe all the numerous varieties of form. The nature of the operation to be performed, and the rules for constructing ploughs that shall be adapted to the different purposes of the cultivator, have been already pointed out in the body of the work; and, therefore, all that is necessary here is to mention those ploughs that are in most general use, in the best cultivated districts.

Swing-Plough.

The *Swing-Plough*, with a feathered sock or share, and a curved mould-board, is almost the only one used in Scotland, and throughout a considerable part of England. The old Scotch plough mentioned in our former article has been laid aside, except in a few of the least improved counties, where it is still found useful, when the soil is encumbered by roots or stones. The swing-plough is drawn with less power than wheel ploughs, the friction not being so great; and it probably admits of greater variations in regard to the breadth and depth of the furrow slice. It is usually drawn by two horses abreast in common tillage; but for ploughing between the rows of the drill culture, a smaller one, drawn by one horse, is commonly employed. A plough of this kind, having a mould-board on each side, is also used both in forming narrow ridges for turnips and potatoes, and in laying up the earth to the roots of the plants, after the intervals have been cleaned and pulverized by the horse and hand hoe. This plough is sometimes made in such a manner, that the mould-board may be shifted from one side to the other when working on hilly grounds; by which means the furrows are all laid in the same direction;—a mode of construction as old as the days of Fitzherbert, who wrote before the middle of the sixteenth century. This is called a *turn-wrest* plough.



Swing-ploughs, similar to the present, have been long known in England. In Blythe's *Improver Improved*, (Edit. 1652,) we have engravings of several ploughs; and what he calls the "plain plough" does not seem to differ much in its principal parts from the one now in use. Amos, in an Essay on *Agricultural Machines*, says that a person named Lummis (whom he is mistaken in calling a Scotchman, see Maxwell's *Practical Husbandman*, p. 191.) "first attempted its construction upon mathematical principles which he learned in Holland; but having obtained a patent for the making and vending of this plough, he withheld the knowledge of these principles from the public. However, one Pashley, plough-wright to Sir Charles Turner of Kirkleatham, having a knowledge of those principles, constructed upon them a vast number of ploughs. Afterwards his son established a manufactory for the making of them at Rotherham. Hence they obtained the name of the Rotherham plough; but in Scotland they were called the Dutch or patent plough."—"At length the Americans, having obtained a knowledge of those principles, either from Britain or Holland, claimed the priority of the invention; in consequence of which, Mr Jefferson, President of the United States, presented the principles for the construction of a mould-board, first to the Institute of France, and next to the Board of Agriculture in England, as a wonderful discovery in mathematics." (*Communications to the Board of Agriculture*, Vol. VI. p. 437.)

Rotherham Plough.

According to another writer, the Rotherham plough was first constructed in Yorkshire in 1720, about ten years before Lummis's improvements. (*Survey of the West Riding of Yorkshire.*)

Small's Plough.

But the present improved swing-plough was little known in Scotland till about the year 1764, when Small's method of constructing it began to excite attention.* This ingenious mechanic formed the mould-board upon distinct and intelligible principles, and afterwards made it of cast-iron. His appendage of a chain has been since laid aside. It has been disputed, whether he took the Rotherham or the old Scotch plough for the basis of his improvements. The swing plough has been since varied a little, in some parts of Scotland, from Small's form, for the purpose of adapting it more completely to particular situations and circumstances. Of late this plough has been made entirely of iron. See Plate I.

Wheel-Ploughs.

*Wheel-Ploughs*, used in many parts of England, are also constructed in a great variety of forms. Their chief recommendation is, that they require less skill in the ploughman; but it is admitted, that the friction caused by the wheels adds to the resistance, and that they are more expensive, and more liable to

* Small's *Treatise on Ploughs and Wheel Carriages*, 1784; and Lord Kames's *Gentleman Farmer*.

Implements be put out of order, as well as to be disturbed in their progress by clods, stones, and other inequalities, than those of the swing kind. Wheel-ploughs, says Dr Dickson (*Practical Agriculture*, Vol. I. p. 7.), should be seldom had recourse to by the experienced ploughman; though they may be more convenient and more manageable for those who are not perfectly informed in that important and useful art.

The Hertfordshire and Kentish *turn-wrest* wheel-plough, as well as the swing-plough, are described by Blythe; and they do not seem to have received much improvement since his time. The former is thought most suitable for general purposes on stiff tenacious soils; and the latter where very deep ploughing is required.

On light loamy and friable soils, where deep ploughing is not necessary, the *Norfolk wheel-plough* will be found convenient and useful: it is compact and light in its form, doing its work with neatness, and requiring only a small power of draught.

Skim Coulter. To the improved common wheel-plough an iron earth-board, firmly screwed to the coulter, has been lately added. It is made use of when ploughing turf, which it takes off by itself, and turns into the furrow, immediately covering it with earth. It is observed, that, by this management, turf at one ploughing has the appearance of a fallow, and harrows nearly as well; but more strength is required in the team. A similar sort of skim coulter may be added to any other plough, and may be useful in turning down green crops and long dung, as well as in trench ploughing. But in most instances it is thought a preferable plan, where the soil is to be stirred to an unusual depth, to make two common swing-ploughs follow each other in the same track; the one before taking a shallow furrow, and the other going deeper, and throwing up a new furrow upon the former.

Two Furrow Ploughs. *Two furrow ploughs* are used in a few places; but are not likely ever to become general. They are constructed either with or without wheels. A plough of this kind was strongly recommended by Lord Somerville, and is used by his Lordship and others, apparently with some advantages. In Blythe's *Improver Improved*, there is an engraving of this plough also. But, with all the improvements made by Lord Somerville, it can never come into competition for general purposes with the present single furrow ploughs; and he admits, that it would be no object to invade the system already established in well cultivated counties; though, where large teams are employed, with a driver besides the ploughman, it would certainly be a matter of importance to use this plough, at least on light friable soils. "Their horses," he says, "will not feel the difference between their own single furrow working one acre, or the well constructed two furrow plough with two acres per day; here is no system deranged, and double work done." (*Communications to the Board of Agriculture*, Vol. II. p. 418.)

Two, Three, and Four Furrow Ploughs. Amos, already mentioned, has gone much beyond this. In his Essay in the Board's Communications formerly referred to, he gives a description with an engraving of a machine, which combines, "two, three, or four ploughs together, for ploughing furrows nine by five inches square." On soils of a tenacity next to clay, "six horses will draw four ploughs; four horses three ploughs, and three horses two ploughs, and every plough to plough an acre a day." It is scarcely necessary to add, that such machines are altogether unfit for agricultural operations; the nature and condition of the soil and surface, varied in ways innumerable, will never permit the general use of them; and even in the few situations where they may be employed, there is reason to believe that ploughing cannot be done cheaper, and certainly not so well as by the two horse single furrow plough.

Miner, &c. Various other implements under the name of ploughs have been constructed for stirring the soil;—such as the *Miner* for following in the furrow of a common plough, and loosening the ground to a greater depth, without bringing up the subsoil;—the *Paring Plough*, and the *Mole* and other sorts of ploughs for draining; some of which shall be afterwards noticed under their proper heads. See Plate II.

### 2. *Cultivator and Grubber.*

Cultivator. A great variety of implements have been contrived for stirring and pulverizing the soil, without turning up a new surface as the plough does. Some of them are used in preparing it for the seed, and others, as horse-hoes, between drilled crops. It were to no purpose to enumerate and describe all these implements; we shall here notice only one machine of very recent introduction which promises to be of much utility. It is said to be an improvement on the Cultivator, and has been called a *grubber*, from its efficiency in bringing weed roots to the surface. It consists of two strong rectangular frames, the one including the other, and nine bars mortised into the inner one, with eleven coulters or tines with triangular sharp-edged dipping feet, four cast-iron wheels, two handles, &c. (See Plate I.) All the coulters are fixed in these bars, except two which are placed in the side beams of the outer frame, and may be set to go more or less deep by means of pins and wedges. It is useful in stirring land on which potatoes or turnips have grown, or that has been ploughed in autumn, or during winter; so that a crop may be sown in spring without further use of the plough. It works as deep as the plough has gone, and, by the reclined position of the coulters, brings to the surface all the weed roots that lurk in the soil. Beans and peas have been sown in spring on the winter furrow, after being stirred by the grubber; and barley also, after turnip, without any ploughing at all. In working fallow it is used with good effect in saving one, two, or more ploughings. This implement is made of different sizes, and may be worked either by four or by two horses.

Grubber.

### 3. *Harrows.*

Common Harrow. The harrows most generally used are of an oblong shape, each containing twenty tines, five or six inches long beneath the *bulls* or bars in which they are inserted. It is still common for every harrow to work separately; and though always two, and sometimes three harrows are placed together, each of them is drawn by its own horse. The great objection to this method is, that it is scarcely possible, especially upon rough ground, to prevent the harrows from starting out of their place, and *riding* on one another. To ob-

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viate this inconvenience, the exterior bulls of each are usually surmounted by a frame of wood, raised so high as to protect it from the irregular motions of its neighbour; but in many instances they are connected by chains or hinges or cross bars, which is a preferable plan. Another objection which has been made to the common harrows is, that the ruts made by the tines are sometimes too near and sometimes too distant from one another; but this is probably not a great fault when the soil requires to be pulverized as well as the seed covered, especially when they are permitted to move irregularly in a lateral direction. Where the soil is already fine, as it ought always to be before grass seeds are sown, lighter harrows are used, which are so constructed, that all the ruts are equidistant. See Plate I.

Harrows that form equidistant ruts.

Brake.

The *brake*, as commonly constructed, is nothing more than a heavier harrow, sometimes in one, and sometimes in two pieces joined together; the tines being in number and length, and in the distance from one another at which they are placed, suited to the nature of the soil on which it is employed.

### 4. *Drill-Machines.*

Drills, various purposes.

The purpose of these ingenious, but often too complicated machines is, to deposit the seed in equidistant rows on a flat surface; on the top of a narrow ridge; in the interval between two ridges; or in the bottom of a common furrow. Corn when drilled is usually sown in the first of these ways; turnips in the second; and peas and beans in the third or fourth. As there is a description and engraving of a patent universal *sowing machine*, in the body of the work, (AGRICULTURE, No. 165,) it is unnecessary to say any thing of later inventions, none of which are in general use. One of the best, for sowing all kinds of corn, was invented by Mr Bailey of Chillingham, * who has paid great attention to the construction of agricultural implements, and applied to their improvement his knowledge, both as a mathematician and agriculturist. The practice of drilling corn does not however seem to be gaining ground, and even where it is found of advantage to have the plants rise in parallel rows, this is sometimes done by means of what is called *ribbing*, a process which will be afterwards described, as more convenient in many cases than sowing with a drilling machine.

Not generally used for sowing corn;

But always in Scotland for turnips,

In Scotland, turnips are universally sown with a drill machine, on ridges twenty-seven or thirty inches broad, usually formed by one *bout* of a common plough. When turnips are extensively grown, the machine is made to sow two of these ridges at once, and two rollers are attached to it, one for smoothing the tops of the ridges before the seed is deposited, and the other for compressing the soil and covering the seed. It is drawn by one horse walking between the ridges, and requiring no other driver than the person who guides the machine, which is simple in its construction, and most expeditious in its operation. See Plate III.

Beans and peas, when sown in rows, are either deposited in the space between two ridgelets which are afterwards reversed to cover them, or in the bottom of a furrow made by a common plough,—in Scotland, usually in that of every third furrow. The implement in most common use for this purpose is extremely simple, and is either wheeled forward by a man, or attached to the common plough itself.

Implements and commonly for Beans and Peas.

### 5. *Horse-Hoes.*

Horse-hoes.

The interval between the rows of drilled turnips, potatoes, and beans and peas, being commonly from 2 to 2½ feet, admits the employment of a horse-hoe, or hoeing-plough. Of this kind of machine there are a great many varieties. A very good one is described in the Northumberland Report, (p. 43); the body is of a triangular form, and contains three coulters and three hoes, or six hoes, according to the state of the soil. A hoe of the same kind is sometimes attached to a small roller, and employed between rows of wheat and barley, from nine to twelve inches distant; it is also used in place of a cultivator, in preparing bean stubbles for wheat in autumn, and in pulverizing lands for barley in spring.

Small Plough and Horse-hoe in one.

Another implement which answers both as a double mould-board plough, and a horse-hoe, is much approved of in the culture of drilled crops; and with some slight alterations it may be also employed as a small plough for taking the earth from the sides of the ridgelets. When it is used as a horse-hoe, the mould-boards are taken off, and two curved cutters or coulters expand from the beam on each side, to a less or greater distance according to the width of the interval between the plants, and approach each other in the bottom of the furrow where the share supplies their place. This machine is well adapted for light soils, and can be set to work very near the rows of plants; it is particularly useful in cutting up annual weeds preparatory to hand-hoeing, which it greatly facilitates. When it is to be employed as a single or double mould-board plough, the cutters are withdrawn. See Plate III.

### 6. *Rollers.*

These are constructed of wood, stone, or cast-iron, and of different dimensions, according to the purposes for which they are used. The *spike-roller* is employed in some places when the soil rises in large masses, difficult to be reduced. The Norfolk *drill-roller*, on which rings of iron are fixed at small distances, is considered an useful implement, as, by forming parallel ruts into which the seed falls, with small ridges between, the seed is better covered than by harrowing alone. For a further account of the roller, and other useful implements, see the article in the body of the work.

Spike-roller.

Drill-roller.

### 7. *Horse-Rakes.*

Rakes.

In those districts where corn is cut with the scythe, the horse-rake is found to be an useful implement for saving manual labour; it is also used for hay. The teeth are of iron, fourteen or fifteen inches in length,

* See *Essay on the Construction of a Plough deduced from Mathematical Principles;* and *Northumberland Report*, p. 48. Edit. 1800.

Implements.

and set five or six inches distant. Its construction is very simple. A man and horse are said to be capable of clearing from twenty to thirty acres in a moderate day's work, disposing the grain in lines across the field, by lifting up the rake and dropping it from the teeth, without stopping the horse.

Work done.

### 8. *Thrashing-Machine.*

Thrashing-machine.

Thrashing-machines (already described in the Encyclopædia under the word THRASHING), are now common in every part of Scotland, on farms where the extent of tillage land requires two or more ploughs; and they are every year spreading more and more in England and Ireland. They are worked by horses, water, wind, and, of late, by steam; and their powers and dimensions are adapted to the various sizes of farms. Water is by far the best power, but, as a supply cannot be obtained in many situations, and as wind and steam require too much expence for most farms, horses are employed more generally than any other power. Where wind-mills are erected, it is found necessary to add such machinery as may allow them to be worked by horses occasionally, in very calm weather; and the use of steam must be confined for the most part to the coal districts.

Different powers employed.

All the essential parts of this machine have been distinctly pointed out in the article referred to, and in the engraving which accompanies it; though several additions and slight alterations have been since introduced. One of the most useful of these, perhaps, is the method of delivering the straw, after it has been separated from the corn by the circular rake, to what is called a *travelling-shaker*, which carries it to the straw-barn. This shaker, which revolves like the endless web said to have been formerly used for conveying the corn to the beaters, is composed of small rods, placed so near as to prevent the straw from falling through, while any thrashed corn that may not have been formerly separated, drops from it in its progress, instead of falling along with it, where it would be trodden down and lost.

Travelling-shaker.

It is well known that the work of horses in thrashing-mills is unusually severe, if continued for any length of time; that they sometimes draw unequally; that they, as well as the machine itself, are much injured by sudden jerks and strains, which are almost unavoidable; and that, from this irregularity in the impelling power, it requires much care in the man who presents the corn to the rollers, to prevent bad thrashing. It is therefore highly desirable that the labour should be equalized among the horses, and the movements of the machine rendered as steady as possible. A method of yoking the horses in such a manner as compels each of them to take his proper share of the labour, has accordingly been lately introduced, and the necessary apparatus, which is neither complicated nor expensive, can be added to any machine worked by animal power. (*Farmer's Magazine*, Vol. XIII. p. 279). See Plate IV.

New method of yoking Horses.

All well-constructed thrashing-mills have one winnowing-machine, which separates the chaff from the corn before it reaches the ground; and a second sometimes receives it from the first, and gives it out ready for market, or nearly so. If the height of the building does not admit of this last addition, a separate winnowing-machine, when the mill is of great power, is driven by a belt from it. In either of these ways there is a considerable saving of manual labour. And with a powerful water-mill, it cannot be doubted, that corn is thrashed and dressed at no more expence than must be incurred for dressing alone, when thrashed with the flail. Besides, the corn is more completely detached from the straw; and, by being thrashed expeditiously, a good deal of it may be preserved in a bad season which would have spoiled in a stack. The great advantage of transferring forty or fifty quarters of grain in a few hours, and under the eye of the owner, from the yard to the granary or market, is of itself sufficient to recommend this invaluable machine, even though there were no saving of expence.

A machine of this kind, to be worked by one or two men, has been lately brought forward, and may probably be found very useful on small farms. It is made for L. 8 or L. 10, and is said to thrash ten or twelve bushels in an hour. (*Id.* p. 409.) See Plate IV.

Hand-Thrashing Mill.

### 9. *Winnowing-Machine.*

This is said to be of Chinese invention, and to have been brought to Europe by the Dutch, from whom it reached Scotland in the early part of the last century. They were first made by a person of the name of Rodgers, near Hawick, in Roxburghshire, who happened to see one in a granary at Leith, in the year 1733, though it would appear that one had been brought from Holland to East Lothian, along with a barley-mill, twenty-two years before. Yet it does not seem to have been then known to farmers, nor did it come into general use till long after 1733; and, in some parts of England and of the north of Scotland, it is not employed even at this day. Two men and three women will dress and measure up into sacks, in about ten hours, from twenty to twenty-five quarters of corn, by means of this machine.

Winnowing-Machine.

### 10. *Chaff-Cutter, and similar Implements.*

Chaff-cutters may be either wrought separately by manual labour, or by being attached to some other machine. This implement, like the operation it performs, is sufficiently simple, though its construction is various. Macdougal's patent chaff-cutter is understood to be one of the most useful of the kind, and may be easily repaired, when necessary, by any common mechanic. Another tool of a similar description, is partially used for cutting turnips, which is often an advantageous practice, especially in feeding sheep of a year old in spring, after they have cast their first teeth. Various contrivances are also adopted by some farmers for cutting or bruising corn for horses, which ought to become a more general practice, particularly for old horses, and such as swallow their corn without mastication. Akin to these inventions is the *steaming apparatus*, which should be considered a necessary appendage to every arable and dairy farm of a moderate size. The advantages of preparing food for live-stock by means of steam, begin now to be generally and justly appreciated.

Chaff-cutter.

Turnip-slicer.

Machines for Cutting or Bruising Corn.

Steaming Apparatus.

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### 11. *Wheel-Carriages.*

Waggons. Waggons, though they may possess some advantages over carts, in long journeys, and when fully loaded, are now admitted to be much less convenient for the general purposes of a farm, and particularly on occasions which require great dispatch, as in harvesting the crop. According to Marshall, the waggons used in Gloucestershire are the best in England. (*Rural Economy of Gloucestershire*). In some places, the *improved Irish car* is employed for light loads, while the waggon continues to be used for other purposes.

Carts. *Carts*, drawn by one or two horses, are, however, the only farm carriages of some of the best cultivated counties, and no other are ever used in Scotland. Their load depends upon the strength of the horses, and nature of the roads; but in every case, it is asserted that a given number of horses will draw a great deal more, according to some one-third more, in single-horse carts than in waggons. Two-horse carts are still the most common among farmers in Scotland; but those drawn by one horse, two of which are always driven by one man, are unquestionably preferable for most purposes. The carriers of the west of Scotland usually load from a ton to a ton and a half on a single-horse cart, and nowhere does it carry less than 12 cwt. if the roads are tolerable.

Corn and Hay Cart. For corn in the straw, and hay, the farmers of the south of Scotland and north of England, use a sparred frame, which is made to fit the same wheels from which the close body of the cart is removed. In other places the close body is retained, and moveable rails attached to it for these loads. See Plate IV.

Carts are varied in their construction to suit different purposes. A very convenient carriage for homework, called a *coup-cart*, discharges its load with great ease and expedition; the fore part of the close body being made to rise up from the shafts on drawing out an iron pin, while the other end sinks, and allows the load to fall to the ground.

Coup-Cart.

Broad Wheels. *Broad wheels*, with conical, or convex rims, are common in England; in Scotland the wheels are generally narrow, though broader ones are beginning to be introduced. Those used for the common, or two-horse carts, are usually about $4\frac{1}{2}$ feet high, and mounted on iron axles. The advantages of broad cylindrical wheels have been illustrated with much force and ingenuity in several late publications. (*Communications to the Board of Agriculture*, Vol. II. and Vol. VII. Part i.)

Reaping-Machines.

### 12. *Reaping-Machines.*

An implement capable of performing the process of reaping corn, is yet a *desideratum* in agricultural machinery, but which will probably be supplied, at least for favourable situations, at no distant period. In all field operations, dispatch, in such a climate as this, is a matter of great importance; but in reaping corn at the precise period of its maturity, the advantages of dispatch are incalculable, especially in those districts where the difficulty of procuring hands, even at enormous wages, aggravates the danger from the instability of the season. It cannot, therefore, fail to be interesting, and we hope it may be also useful, to record some of the more remarkable attempts that have been made towards an invention so eminently calculated to forward this most important operation.

Implements

Mr Boyce's. The first attempt of this kind, so far as we have learned, was made by a Mr Boyce, who obtained a patent for a reaping-machine fifteen or twenty years ago. This machine was placed in a two-wheeled carriage, somewhat resembling a common cart, but the wheels were fixed upon the axle, so that it revolved along with them. A cog-wheel, within the carriage, turned a smaller one at the upper end of an inclined axis, and at the lower end of this was a larger wheel, which gave a rapid motion to a pinion fixed upon a vertical axis, in the fore part of the carriage, and rather on one side, so that it went before one of the wheels of the carriage. The vertical spindle descended to within a few inches of the surface of the ground, and had there a number of scythes fixed upon it horizontally.

This machine, when wheeled along, would, by the rapid revolution of its scythes, cut down a portion of the corn growing upon the ground over which it passed, but having no provision for gathering up the corn in parcels and laying it in proper heaps, it was wholly unsuited to the purpose.

Mr Plucknet's. An agricultural implement maker of London, Mr Plucknet. attempted some years afterwards to improve this machine. The principal alteration he made, was in substituting for the scythes a circular steel plate, made very sharp at the edge, and notched on the upper side like a sickle. This plate acted in the same manner as a very fine toothed saw, and was found to cut the corn much better than the scythes of the original machine. See Plate V.

Mr Gladstones. A description and drawing of a machine, invented by Mr Gladstones of Castle Douglas, in the Stewartry of Kircudbright, are given in the Farmer's Magazine, Vol. VII. p. 273. It operated upon nearly the same principles with Mr Plucknet's; but Mr Gladstones made it work much better by introducing a circular table, with strong wooden teeth notched below all around, which was fixed immediately over the cutter, and parallel to it. The use of these teeth was to collect the corn and retain it till it was operated on by the circular cutter. The corn when cut was received upon this table, and, when a sufficient quantity was collected, taken away by a rake or sweeper, and laid upon the ground beneath the machine, in separate parcels. To this machine was added a small circular wheel of wood covered with emery, which, being always in contact with the great cutter at the back part, or opposite side to that where the cutting was performed, kept it constantly ground to a sharp edge.

Mr Salmon's. The next attempt was made by Mr Robert Salmon of Woburn, Bedfordshire, whose invention, it is said, promised better than those we have mentioned. It was constructed upon a totally different principle, as it cut the corn by means of shears; and it was provided with a very complete apparatus for laying it down in parcels as it was cut. See Plate V.

Mr Smith's. The latest, and by much the most ingenious, as well as promising machine of this kind, of which we have received any account, is that constructed by Mr Smith, of the Deanston Cotton Works, Perthshire. Mr Smith's perseverance, his successive im-

Implements ‖ Farm Houses.

provements, and ingenious yet simple contrivances for remedying defects, afford strong grounds to hope that he will ultimately succeed in rendering his machine a most valuable acquisition to agriculturists. He made the first trial of his machine, (See Plate VI.) upon a small scale, during the harvest of 1811. It was then wrought by two men. In 1812, he constructed one upon a larger scale, to be wrought by a horse; but though he cut down several acres of oats and barley with considerable ease, it was found that, when met by an acclivity, the horse could not move the machine with proper effect. In 1813, he made a more successful attempt, with an improved machine, worked by one man and two horses; and last year, (1814) it was still farther improved by an additional apparatus, tending to regulate the application of the *cutter*, when working on an uneven surface.

The *cutter* of this machine is circular, and operates horizontally; it is appended to a drum connected with the fore part of the machine, its blade projecting some inches beyond the periphery of the lower end of the drum (See Plate VI.); and the machine is so constructed as to communicate, in moving forward, a rapid rotatory motion to this drum and cutter, by which the stalks are cut, and, falling upon the drum, are carried round and thrown off in regular rows. This most ingenious piece of machinery will cut about an English acre per hour, during which time the cutter requires to be four times sharped with a common scythe stone. The expence of this machine is estimated at from L. 30 to L. 35. If properly managed, it may last for many years; only requiring a new *cutter* every two or three years, a repair which cannot cost much.

## Sect. II. Farm-Houses.

Farm-Houses.

Suitable farm buildings are scarcely less necessary to the husbandman than implements and machinery, and might, without much impropriety, be classed along with them, and considered as one great stationary machine, operating more or less on every branch of labour and produce. There is nothing which marks more decidedly the state of agriculture in any district than the plan and execution of these buildings.

Situation.

In erecting farm-houses, the first thing that deserves notice is their situation, both in regard to the other parts of the farm, and the convenience which they ought themselves to possess. In general, it must be of importance on arable farms, that the buildings should be set down at nearly an equal distance from the extremities; or so situate that the access from all the different fields should be easy, and the distance from those most remote no greater than the size of the farm renders unavoidable. The advantages of such a position in saving labour, are too obvious to require illustration; and yet this matter is not nearly so much attended to as its importance deserves. In some cases, however, it is advisable to depart from this general rule, of which one of the most obvious is, when a command of water for a thrashing-mill, and other purposes, can be better secured in another quarter of the farm.

Farm-Houses. Form.

The form most generally approved for a set of offices, is that of a square, or rather a rectangular parallelogram, the houses being arranged on the north, east, and west sides, and the south side fenced by a stone wall, to which low buildings for calves, pigs, &c. are sometimes attached. The space thus inclosed is usually allotted to young cattle: these have access to the sheds on one or two sides, and are kept separate according to their size or age, by one or more partition-walls. The farmer's dwelling house stands at a short distance from the offices, and frequently commands a view of the inside of the square; and cottages for servants and labourers are placed on some convenient spot, not far from the other buildings.

The number and arrangement, as well as the size of the different houses, must depend, in some degree, on the extent of the farm, and the general management. It is, therefore, only necessary to notice particularly those which are indispensable in every case on an arable farm, and the degree of accommodation they should afford.

Barn.

The *Barn* is always set down so as to be as convenient as possible for the stack-yard, wherever corn is put up in stacks instead of being immediately carried from the field to the barn itself. Relatively to the other buildings, its situation may be varied according to circumstances; but two things should be attended to; first, its contiguity to the granary; and second, its facility of access for furnishing straw to the cattle-houses. In the plan delineated in Plate VII., it is placed in the middle of the north range, with one end projecting into the stack-yard, and the other, where the straw is lodged, on a line with stables on one side, and cattle-houses on the other, and having a door opening towards the straw-yards. As it is to be understood throughout this description, that a thrashing-mill is employed, from 20 to 30 feet within walls, on the length of this side of the square, will generally be sufficient for the straw-house. The height of the barn must be such as to allow at least one winnowing machine to be attached to the mill, and its length is determined by the size of the farm.

Straw-house.

Granary.

A *Granary* is an indispensable accommodation on all tolerably large farms, and is commonly, though in many cases improperly, placed above the cart-sheds, to be afterwards noticed. From experience and observation we would recommend that the granary should be under the roof of the barn, immediately above the floor on which the machine works; and that the corn should be raised to it from the ground-floor, either by the thrashing-mill itself, or a common windlass, easily worked by one man. When it is to be taken out and carried to market, it may be lowered down upon carts, with the utmost facility and dispatch. There is evidently no greater expence incurred by this arrangement; for the same floor and height of side-walls that must be added to the barn, are required in whatever situation the granary may be; and it possesses several advantages. Owing to its being higher than the adjacent buildings, there is a freer circulation of air, and less danger of pilfering, or of destruction by vermin; the corn can be deposited in it as it is dressed, without being exposed to the weather, while the saving of la-

Farm-Houses.

bour is in most cases considerable. This plan has been lately recommended by several agricultural writers, * and has been found exceedingly convenient in practice.

Stables.

*Stables* are now constructed in such a manner that all the horses stand in a line with their heads towards the same side-wall, instead of standing in two lines, fronting opposite walls, as formerly. Those lately erected are at least sixteen feet wide within walls, and sometimes eighteen, and the width of each stall upon the length of the stable is commonly five feet. To save a little room stalls of nine feet are sometimes made to hold two horses, and, in that case, the manger and the width of the stall are divided into equal parts by what is called a half trevice, or a partition about half the depth of that which separates one stall from another. By this contrivance, each horse indeed eats his food by himself; but the expence of single stalls, is more than compensated by the greater ease, security, and comfort of the horses. The trevices or partitions which divide the stalls, are of deals two inches thick, and about five feet high; but, at the heads of the horses, the partition rises to the height of seven feet, and the length of the stall is usually from seven to eight feet.

The manger is generally continued the whole length of the stable. It is about nine inches deep, twelve inches wide at the top, and nine at the bottom, all inside measure, and is placed about two feet four inches from the ground. Staples or rings are fixed the breast of the manger, to which the horses are tied.

The rack for holding their hay or straw is also commonly continued the whole length of the stable. It is formed of upright spars, connected by cross rails at each end, and from two, to two and a half feet in height. The rack is placed on the wall, about one foot and a half above the manger, the bottom almost close to the wall, and the top projecting outwards so as to form an angle with it of twenty or twenty-five degrees. The spars are sometimes made round, and sunk into the cross rails, and sometimes square. In a few stables lately built, the round spars turn on a pivot, which facilitates the horse's access to the hay, without requiring the interstices to be so wide as to permit him to draw it out in too large quantities.

Immediately above the racks is an opening in the hay-loft, through which the racks are filled. When it is thought necessary, this may be closed by boards moving on hinges.

Behind the horses, and about nine feet from the front wall, is a gutter, having a gentle declivity to the straw-yard or urine-pit. Allowing about a foot for this, there will remain a width of eight feet to the back wall, if the stable be eighteen feet wide; a part of which, close to the wall, is occupied with corn-chests and places for harness.

In some of the best stables, the racks occupy one of the angles between the wall and trevices, and form the quadrant of a circle. The spars are perpendicular, and wider placed than in the hanging racks. The hay-seed falls into a box below, instead of being dropped on the ground, or incommoding the eyes and ears of the horses.

With a view to save both the hay and the seed, it is an advantage to have the hay-stack so near the stable as to admit of the hay being thrown at once upon the loft. In some stables there is no loft, and the hay is stored in a separate apartment. The floor is, for the most part, paved with undressed stones; but, in some instances, the space from the gutter to the back wall is laid with flags of freestone.

Cattle-Houses.

According to the plan we are describing, *Cattle-houses* are placed on the other side of the straw-house, and, with a root-house, complete the north side of the square. The extent of these, it is evident, depends not only on the size of the farm, but on the general management, and must vary according as rearing, fattening, or dairy cattle, form the principal object. To avoid prolixity, let it be understood that this part of the range is allotted to fattening cattle. There are three ways in which the cattle are placed; first, in a row towards one of the side walls; second, in two rows, either fronting each other, with a passage between, or with their heads towards both side walls; and, third, across, or upon the width of the house, in successive rows, with intervening passages for feeding and removing the dung. In the first plan, it is usual to have openings in the walls, through which they are supplied with turnips, otherwise they must necessarily be served from behind, with much inconvenience, both to the cattle-feeder and the cattle themselves. The plan that is most approved, and now becoming general when new buildings are erected, is to fix the stakes to which the cattle are tied about two and a half or three feet from the wall, which allows the cattleman, without going among them, to fill their troughs successively from his wheelbarrow or basket, with much ease and expedition. It is also a considerable improvement to keep the cattle separate, by partitions between every two. This will in a great measure prevent accidents, and secure the quiet animals from being injured by the vicious; for, in these double stalls, each may be tied up to a stake placed near the partition, so as to be at some distance from his neighbour; and it is easy to lodge together such as are alike in size and in temper. The width of such stalls should not be less than $7\frac{1}{2}$ feet, and the depth must be regulated by the size of the cattle.

Root-House.

Wherever a number of cattle are fed, an apartment is required for containing turnips, potatoes, &c. when brought from the field, until they are dealt out into the troughs. This apartment is placed either on the line of the cattle-houses, or begins another side of the square, at the angle of the junction of the two sides. The outer-door ought to be so large as to admit a loaded cart; and there is an inner-door that opens into the feeder's walk along the heads of the cattle. At the other end of this, a door opens into the straw-house; so that their food and litter are noway exposed to the weather, and the labour of the feeder is greatly diminished.

Cattle and Cart-Sheds.

The east and west sides of the square consist chiefly of sheds for the straw-yard cattle, and cart-sheds.

* Dickson's *Practical Agriculture*, Vol. I. p. 48, and *General Report of the Agricultural State of Scotland*, Vol. I. p. 141.

Farm-houses.

But stables for young horses, riding-horses, and for separating the sick from the others, may be placed upon that side which connects with the common stable already described; and, in like manner, a part of the opposite side, connecting with the cattle-houses, may be allotted to cows; or, if necessary, the feeding-houses may be continued. The cattle-sheds are open towards the straw-yards, and the cart-sheds outwards to the road. On one of these sides there should be a close apartment for small tools, and another for preparing corn and roots by steam, which may also serve for other purposes. In some convenient place near the stables and cattle-houses, or immediately over them, there should be sleeping-rooms for the servants who have the charge of them, that they may be at hand in case of accidents during the night.

Hog-Styes and Poultry-Houses.

Along the wall which completes the inclosure, such low buildings may be set down, particularly hog-styes and poultry-houses, as may be thought desirable. These styes should open behind into the straw-yards, to which the hogs should have access for picking up corn left on the straw, and what turnips, clover, &c. are refused by the cattle. When they are kept in great numbers, it may be necessary to allot them a range of styes, with yards in front, in another place, as is commonly done by gentlemen farmers; but it is absurd fastidiousness, in a rent-paying farmer, to exclude these profitable animals from a place where a few of them will make themselves fat without a shilling of expence, and without any real injury to the cattle among which they feed.

It will be seen from the engraving, (Plate VII.) that a road, which should be always kept in good order, goes along three sides of this square, from which there is access to the houses, instead of entering through the straw-yards from the inclosed area. All the houses in which live stock are kept have an opening behind towards the straw-yards, for carrying out their dung.

This plan, which, with slight variations, required by circumstances, is common in the north of England and south of Scotland, is meant to combine convenience with economy, and is well adapted to most arable farms in the occupancy of tenants. Proprietors who farm, sometimes choose to add several other buildings, and, at the same time, to vary a little their distribution. Thus, it is common to separate the straw-yards from the sides of the square, by a cart-way, towards which all the doors open, and the hog-styes with yards are usually placed behind one of the sides where they are least exposed to observation.

Watering-Troughs.

In every case, it is absolutely necessary that there should be water in or near the area. In the plan delineated in Plate VII. a pump is placed at the end of the wall which divides the area, and along this wall are fixed troughs, to which the cattle on each side have access at all times.

Urine-Pit.

When a great number of cattle are fed at the stake, it is necessary to have a reservoir near the square to receive their urine. The urine is either applied to the land in its liquid state, or earth, peat-moss, &c. are thrown into the pit in such quantities as may be necessary to absorb it. Sometimes the reservoir is sunk below the area, and the urine raised by a pump, and spread over the straw-yard. But, on those arable farms where no more cattle are reared or fattened, and no more turnips consumed at the homestead, than what are needed for converting the straw into manure, a reservoir for urine is not required; the whole of it being absorbed by the straw as it is dropped.

Hammels.

The practice of feeding cattle in small sheds and straw-yards, or what are called *hammels* in Berwickshire, deserves to be noticed with approbation, when saving of expence is not a paramount object. Two cattle are usually kept together, and go loose, in which way they are thought by some to thrive better than when tied to a stake, and, at the same time, feed more at their ease than when a number are kept together, as in the common straw-yards. All that is necessary is, to run partition-walls across the sheds and yards already described, or, if these are allotted to rearing stock, one side of the square, separated by a cart-way from the straw-yards, is appropriated to these hammels.

Smith's and Wright's Shops.

On large farms, a smith's and a wright's shop are found exceedingly convenient, even though used only one or two days a-week. Much time is lost in going to a distance to the residence of these necessary mechanics; and it is now not uncommon to have houses furnished with the necessary accommodations on farms of this description, where the smith attends at stated intervals, and the wright when wanted. It is better to set down these houses at a little distance, than to place them on the square, whence, among other inconveniences, the danger from fire is a sufficient reason for excluding them.

Cottages.

The cottages for farm-servants, which are usually set down in a line, at not an inconvenient distance from the offices, ought to contain each of them at least two apartments with fire-places, though, in some of the best cultivated counties, there is only one chimney, and no other division than what is made by the furniture. But better accommodation for this useful and meritorious class is now generally allowed in erecting new buildings. Every cottage has a small kitchen-garden adjoining; and as farm-servants in the southern counties of Scotland have each of them a cow, kept all the year on the farm as part of their wages, it is common to attach a byre for them to the range of cottages, and sometimes also hog-styes, and apartments for fuel.

Dwelling-House.

It is unnecessary to say any thing of a farmer's dwelling-house, as the size and accommodations are very little different from those of other dwelling-houses possessed by people of the same property or income. It is only on dairy farms that particular apartments are necessarily appropriated to the business of a farm; and these shall be described under a separate article. See Dairy.

Most of the farm-buildings recently erected in the best cultivated counties are covered with slate. A thatched roof is still common for cottages, though for these also slate is beginning to be preferred. One cause of the comparative sterility of land in former times, was the great quantity of straw that was withdrawn from the food or litter of cattle, and used as thatch, instead of being converted into manure.

Repairs.

Tenants holding on leases for a term of years are

Farm-houses || Fences.

usually taken bound to keep all the houses on a farm in sufficient repair during their occupancy, and to leave them so at their removal, having received them in such a state at their entry. It is common to have them inspected by tradesmen, both at the beginning and expiration of a lease, for the purpose of determining their condition, and awarding such repairs as may be necessary. In some districts, it is the practice to ascertain their value at the commencement of a lease, the tenant being bound at his removal, when a second valuation takes place, to pay or to accept the difference. But the objections to this method are obvious. If no change has taken place, during the currency of the lease, in the price of materials and wages of labour, the tenant suffers by being called upon to make good the decay occasioned by the lapse of time, which ought to be considered as covered by his rent. If, on the other hand, both materials and labour have advanced in price, as has been the case of late years, the proprietor may be obliged to make a large payment to the removing tenant, even though the houses are rendered of less real value, not only by time, but by carelessness or dilapidations.

## Sect. III. Fences.

Fences.

Next to implements and machinery, and suitable buildings, fences are in most situations indispensable to the profitable management of arable land. They are not only necessary to protect the crops from the live stock of the farm, but often contribute, in no small degree, by the shelter they afford, to augment and improve the produce itself. On all arable farms, on which cattle and sheep are pastured, the ease, security, and comfort, which good fences give, both to the owner and the animals themselves, are too evident to require particular notice. And as there are few tracts so rich as to admit of crops being carried off the land for a succession of years, without the intervention of green crops consumed where they grow, fences, of some description or other, can very rarely be dispensed with, even in the most fertile and highly improved districts.

Much neglected.

There is no branch of husbandry so generally mismanaged as this. No district, of any considerable extent, perhaps, can be named, in which one does not see the greater part of what are called fences, not only comparatively useless, but wasteful to the possessor of the lands which they occupy, and injurious both to himself and his neighbours, by the weeds which they shelter. This is particularly the case with thorn hedges, which are too often planted in soils where they can never, by any management, be expected to become a sufficient fence; and which, even when planted on suitable soils, are in many cases so much neglected when young, as ever afterwards to be a nuisance, instead of an ornamental, permanent, and impenetrable barrier, as, with proper training, they might have formed in a few years.

General Rules.

Until of late inclosures have too often been made without much regard to the size of the farm, the exposure, the form of the fields, and the equability of the soil. This is the more to be regretted in the case of live fences, which ought to endure for a long course of years, and which cannot be eradicated without considerable expence. It is impossible, indeed, to lay down any rules on this subject that would be generally applicable; but upon a little reflection it must be evident, that the size of the field should be suited not only to the extent of the farm, but also to the nature of the soil, which ought to prescribe the course of management, whether in alternate white or green crops, or with the intervention of several years pasturage;—that the exposure of the land should be considered, in order that the fences may give the shelter that is most required;—that the form of the field should be such, as to render it most accessible from the farm buildings, and that it may be cultivated at the least expence, the lands or ridges not being too short, nor running out into angles at the points where the fence takes a different direction;—and that the soil of the inclosure should be as nearly alike throughout as possible, that the whole field may be always under the same kind of crop. It must, in general, be a matter of consequence to have water in every inclosure; but this is too obvious to escape attention.

Hedge-row Trees disapproved of.

Notwithstanding the garden-like appearance which trees growing in hedges give to the landscape, it seems to be agreed by the most intelligent agriculturists, that they are extremely hurtful to the fence, and for some distance to the crops on each side; and it is evident, that, in many instances, the highways, on the sides of which they often stand, suffer greatly from their shade. It has therefore been doubted, whether such trees be profitable to the proprietor, or beneficial to the public;—to the farmer they are almost in every case injurious, to a degree beyond what is commonly imagined.

Number of Inclosures.

In the subdivisions of an arable farm, whatever may be the kind of fence which it is thought advisable to adopt, we would recommend that particular attention be paid to the course of crops which the quality of the soil points out as the most advantageous; and that upon all farms, not below a medium size, there should be twice the number of inclosures that there are divisions or *breaks* in the course. Thus, if a six years' rotation be thought the most profitable, there should be twelve inclosures, two of which are always under the same crop. One very obvious advantage in this arrangement is, that it tends greatly to equalize labour, and, with a little attention, may contribute much to equalize the produce also. On large farms, where all the land under turnips and clover, for instance, is near the extremity of the grounds, or at a considerable distance from the buildings, supposed to be set down near the centre, it is clear, that the labour of supplying the house and straw-yard stock with these crops, as well as the carriage of the manure to the field, is much greater than if the fields were so arranged, as that the half of each of these crops had been near the offices. But by means of two fields for each crop in the rotation, it is quite easy to connect together one field near the houses with another at a distance, and thus to have a supply at hand for the home stock, while the distant crops may be consumed on the ground. The same equalization of labour must be perceived in the cultivation of the corn fields, and in harvesting the crops. The time lost in travelling to some of the

Fences.

fields, when working by the plough, is of itself a matter of some consequence on large farms. But the advantages of this arrangement are not confined to the equalization and economy of labour; it may also, in a great measure, render the annual produce uniform and equable, notwithstanding a considerable diversity in the quality of the soil. A field of an inferior soil may be connected with one that is naturally rich, and in the consumption of the green crops, as well as in the allowance of manure, the poor land may be gradually brought nearer, in the quantity and quality of its produce, to the rich, without any injury to the latter. Thus a field under turnips may be so fertile, that it would be destructive to the succeeding corn crop to consume the whole or the greater part on the ground; while another may be naturally so poor, or so deficient in tenacity, as to make it inexpedient to spare any part for consumption elsewhere. By connecting these two under the same crop,—by carrying from the one what turnips are wanted for the feeding-houses and straw-yards, and eating the whole crop of the other on the ground with sheep, the ensuing crop of corn will not be so luxuriant on the former as to be unproductive, while the latter will seldom fail to yield abundantly. The same plan will also be advantageous in the case of other crops. Hay or green clover may be taken from the richer field, and the poorer one depastured; and on the one wheat may succeed both turnips and clover, while the more gentle crops of barley and oats are appropriated to the less fertile field.

These observations are particularly applicable to turnip soils, of such a quality as not to require more than one year's pasturage, and which are therefore cultivated with corn and green crops alternately; but the same principle may be extended to clay lands, and such as require to be depastured two or more years in succession.

Fences useful as Drains.

It is scarcely necessary to add, that upon wet soils, where hedges are employed as fences, it is of importance that the ditches be drawn in such a direction as to serve the purposes of drains, and also that they may receive the water from the covered drains that may be required in the fields contiguous. According as the line of the fence is more or less convenient in this respect, the expence of draining may be considerably diminished or increased.

Walls and Thorn Hedges:

The most common fences, of a permanent character, are *stone walls* and *white thorn hedges*. Stone walls have the recommendation of being an immediate fence; but the disadvantage of going gradually to decay, and of requiring to be entirely rebuilt, in some cases every twenty years, unless they are constructed with lime mortar, which is in many districts much too expensive to be employed in erecting common fences. White thorn hedges, on the contrary, though they require several years to become a fence of themselves, may be preserved at very little expence afterwards in full vigour for several generations.

Having thus thrown out a few hints of a general nature, we beg to refer the reader, for an account of the different sorts of fences commonly employed, to the body of the work (AGRICULTURE, P. III. § 10), and shall only observe here, that, in many instances, there seems to be a radical error in the first construction and subsequent management of hedge-fences in particular, which might be easily removed under appropriate covenants of lease. The expence of inclosing, and, of course, the direction and construction of the fences, ought to be undertaken in almost every case by the proprietor, not merely for the sake of relieving the tenant from a burden which may be incompatible with his circumstances and professional duties, but also from a principle of economy on the part of the landlord. Whatever may be the tenant's knowledge and capital, it is not to be expected that his views should extend much beyond his own accommodation during his temporary occupation; whereas the permanent interest of the landlord requires, not so much a minute attention to economy in the first instance, as that the amelioration shall be as complete and as durable as possible. The tenant's outlay on fences must inevitably be returned by a diminution of the yearly rent, and probably with a large profit for the first advance of the money; while, at the same time, that money may be expended in an improvement which is neither so complete nor so lasting as it might have been rendered, had it been done at the expence, and under the direction of the proprietor.

by whom constructed,

But another error of the same kind is probably still more common, and by far more pernicious to landholders. The fences are to be kept in repair by the tenant; which, in so far as regards stone walls, is a stipulation no way objectionable. But it often happens that a landlord, even though he runs a hedge-fence at his own expence, leaves it to be trained up by the tenant without his interference; and the consequence is, that, in perhaps nine cases out of ten, it never becomes a sufficient fence at all;—that the original cost is lost for ever; and that the land which it occupies is not only unproductive, but actually a nuisance. Besides, it is evidently improper to require of a tenant to rear up a good fence, commonly by a greater outlay than was required for forming it, when the half of his lease perhaps must elapse before he can derive much benefit from it. This mistake on the part of proprietors is probably the principal cause of the badness of hedge-fences; for if they are neglected when the plants are young,—if cattle are allowed to make gaps,—water permitted to stagnate in the ditch,—or weeds to grow unmolested on the face of the bank, no labour or attention afterwards will ever make an equal and strong fence. As it is well known how difficult, or rather impossible, it is to enforce this care by any compulsory covenants, the best plan for both parties is that which is adopted in some districts, where hedges are reared at the mutual expence of landlord and tenant,—the thorns, while they require it, being protected by rails, or otherwise, so as to give the tenant all the advantages of a complete fence in the mean time. In this case he cannot justly complain that he pays a share of the expence, and this payment furnishes the strongest motive for preserving the young thorns from damage, and for training them with such care, as to become a complete fence in the shortest possible period.

and kept in repair.

Fences ‖ Tillage.

Laws regarding Fences.

The provisions of the law of Scotland, in regard to inclosing, have promoted this invaluable improvement in that country. It holds out the greatest facilities, both for straightening the boundaries of conterminous properties, and for erecting march-fences, by obliging every proprietor, upon due notice from his neighbour, to defray half the charges of such a fence as the nature of the soil and surface may render most eligible. By an act in 1686, cattle must be constantly herded during the day, if the pastures be not inclosed, and are ordered to be kept during the night in houses, folds, or inclosures; a fine is exigible from the owner, if his cattle trespass on his neighbour's lands,—so much for every animal,—over and above the damage done, even where there are no fences; and, by the statute 1695, heavy penalties are denounced against such as destroy fences.

### Sect. IV. Tillage.

Tillage. General Observations.

As the operations connected with tillage must necessarily be regulated by the condition of the soil and surface, and the crops to be cultivated, as to which we shall have occasion to treat in a subsequent section, all that is at present necessary is, to offer a few general observations, premising, that we here take it for granted, that all those obstructions which fall to be considered under the chapter on Natural Pastures and Wastes, have either never existed, or been already removed.

It is well known to every husbandman, that clayey or tenacious soils should never be ploughed when wet; and that it is almost equally improper to allow them to become too dry; especially if a crop is to be sown without a second ploughing. The state in which such lands should be ploughed is that which is commonly indicated by the phrase, "between the wet and the dry,"—while the ground is slightly moist, mellow, and the least cohesive.

Winter Ploughing.

In ploughing the first time for fallow or green crops, all good farmers begin immediately after harvest, or after wheat sowing is finished; and when this land has been gone over, the old tough swards, if there be any, are next turned up. The reasons for ploughing so early are sufficiently obvious; as the frosts of winter render the soil more friable for the spring operations, and assist in destroying the weed roots. In some places, however, the first ploughing for fallow is still delayed till after the spring seed-time.

In the following remarks, the *swing-plough*, drawn by two horses, is to be understood as the one employed, if no other be mentioned; and the practices of some of the English counties having been described in the body of the work, we shall here confine ourselves, for the most part, to those of the north of England and the south-east of Scotland.

Three different points require particular attention in ploughing; 1. the breadth of the slice to be cut; 2. its depth; and 3. the degree in which it is to be turned over;—which last circumstance depends both upon the construction of the plough, particularly the mould-board, and the care of the ploughman.

The breadth and depth of the furrow-slice are regulated by judiciously placing the draught on the nozzle or bridle of the plough; setting it so as to go more or less deep, and to take more or less land or breadth of slice, according as may be desired. In general, the plough is so regulated that, if left to itself, and merely kept from falling over, it would cut a little broader and a little deeper than is required. The coulter is also placed with some inclination towards the left or land side, and the point of the sock or share has a slight tendency downwards.

Tillage.

Different modes of Ploughing.

The degree to which the furrow-slice turns over, is in a great measure determined by the proportion between its breadth and depth, which for general purposes is usually as three is to two; or when the furrow is nine inches broad it ought to be six inches in depth. When the slice is cut in this proportion, it will be nearly half turned over, or recline at an angle of 40 or 45 degrees: and a field so ploughed will have its ridges longitudinally ribbed into angular drills or rideglets. But if the slice is much broader in proportion to its depth, it will be almost completely overturned, or left nearly flat with its original surface downwards; and each successive slice will be somewhat overlapped by that which was turned over immediately before it. And finally, when the depth materially exceeds the width, each furrow-slice will fall over on its side, leaving all the original surface bare, and only laid somewhat obliquely to the horizon.

The *first* of these modes of ploughing, where the breadth and depth are nearly in the proportion already mentioned, is the best adapted for laying up stubble land after harvest, when it is to remain during winter exposed to the mellowing influence of frost, preparatory to fallow or turnips. The *second* or shallow furrow, of considerable width, as five inches in depth by eight or nine wide, is understood to answer best for breaking up old leys; because it covers up the grass turf and does not bury the manured soil. The *third* is a most unprofitable and uselessly slow operation, which ought seldom or never to be adopted. The most generally useful breadth of a furrow-slice is from eight to ten inches, and the depth, which ought to be seldom less than four inches, cannot often exceed six or eight inches, except in soils uncommonly thick and fertile. When it is necessary to go deeper, as for carrots and some other deep rooted plants, a trench ploughing may be given by means of second plough following in the same furrow. Shallow ploughing ought always to be adopted after turnips are eaten on the ground, that the manure may not be buried too deep; and also in covering lime,—especially if the ground has been pulverized by fallowing, because it naturally tends to sink in the soil. In ploughing down farm yard dung, it is commonly necessary to go rather deep, that no part of the manure may be left exposed to the atmosphere. In the first ploughing for fallow or green crops, it is advisable to work as deep as possible, and no great danger is to be apprehended, though a small portion of the subsoil be at that time brought to the surface.

Lands or Ridges.

The furrow-slices are generally distributed into beds, varying in breadth according to circumstances; these are called *ridges* or *lands*, and are divided from one another by gutters or open furrows. These last serve as guides to the hand and eye of the sower, to the reapers, and also for the application of manures

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in a regular manner. In soils of a strong or retentive nature, or which have wet close subsoils, these furrows serve likewise as drains for carrying off the surface water, and being cleared out, after the land is sown and harrowed, have the name of *water-furrows.*

Ridges are not only different in breadth, but are raised more or less in the middle on different soils. On clayey retentive soils, the great point to be attended to is the discharge of superfluous water. But narrow stitches of from three to five feet, are not approved off in some of the best cultivated counties. In these a breadth of fifteen or eighteen feet, the land raised by two *gatherings* of the plough, is most commonly adopted for such soils; such ridges being thought more convenient for manuring, sowing, harrowing, and reaping, than a narrower one; and the water is drained off quite as effectually.

On dry porous turnip soils, ridges may be formed much broader; and were it not for their use in directing the labourers, may be, and sometimes are, dispensed with altogether. They are often thirty or thirty-six feet broad, which in Scotland are called *band-win* ridges, because reaped by a band of shearers, commonly six, served by one binder. If it be wished to obliterate the intermediate furrows, this may be done by casting up a narrow ridgelet or single bout drill between the broad ridges, which is afterwards levelled by the harrows.

Forming of Ridges.

With regard to the mode of forming these ridges, straight and of uniform breadth,—let us suppose a field perfectly level that is intended to be laid off into ridges of any determinate breadth. The best ploughman belonging to the farm conducts the operation, with the aid of three or more poles shod with iron, in the following manner: The first thing is to mark off the head ridges, on which the horses turn in ploughing, which should in general be of an equal breadth from the bounding lines of the field, if these lines are not very crooked or irregular. The next operation, assuming one straight side of the field, or a line that has been made straight, as the proper direction of the ridges, is to measure off from it with one of the poles (all of them of a certain length or expressing specific measures), half the intended breadth of the ridge, if it is to be gathered, or one breadth and a half if to be ploughed flat; and there the ploughman sets up a pole as a direction for the plough to enter. On a line with this, and at some distance, he plants a second pole, and then in the same manner a third, fourth, &c. as the irregularity of the surface may render necessary, though three must always be employed,—the last of them at the end of the intended ridge, and the whole in one straight line. He then enters the plough at the first pole, keeping the line of poles exactly between his horses, and ploughs down all the poles successively; halting his horses at each, and replacing it at so many feet distant as the ridges are to be broad; so that when he reaches the end of the ridge, all his poles are again set up in a new line parallel to the first. He returns however along his former track, correcting any deviations, and throwing a shallow furrow on the side opposite to his former one These furrows, when reversed, form the crown of the ridge, and direct the ploughmen who are to follow. The same operations are carried on until the whole field is marked out. This is called *feiring* in Scotland, and *striking the furrows* in England. It is surprising with what accuracy these lines are drawn by skilful ploughmen.

Another method has been adopted for the same purpose, which promises to be useful with less experienced workmen. A stout lath or pole, exactly equal in length to the breadth of the intended ridge, is fixed to the plough, at right angles to the line of the draught, one end of which is placed across the handles exactly opposite the coulter, while the other end projects towards the left hand of the ploughman, and is preserved in its place by a rope passing from it to the collar of the near side horse. At the outer end of the lath, a coulter or harrow tine is fixed perpendicularly, which makes a trace or mark on the ground as the plough moves onwards, exactly parallel to the line of draught. By this device, when the plough is *feiring* the crown of one ridge, the marker traces the line on which the next ridge is to be *feired*. (*General Report of Scotland*, Vol. I p. 354.)

With regard to the direction and the length of ridges, these points must evidently be regulated by the nature of the surface, and the size of the field. Short angular ridges, called *butts*, which are often necessary in a field with irregular boundaries, are always attended with a considerable loss of time, and ought to be avoided as much as possible.

In ploughing steep land it is advisable to give the ridges an inclination towards the right hand at the top, by which, in going up the acclivity, the furrow falls more readily from the plough, and with less fatigue to the horses. Another advantage of forming ridges in a slanting direction on such land is, that the soil is not so apt to be washed down from the higher ground, as if the ridges were laid at right angles. Wherever circumstances will permit, the best direction however is due north and south, by which the grain on both sides of the ridge enjoys nearly equal advantages from the influence of the sun.

The land being thus formed into ridges, is afterwards cultivated without marking out the ridges anew, until the inter-furrows have been obliterated by a fallow or fallow crop. This is done by one or other of the following modes of ploughing: 1. If the soil be dry and the land has been ploughed flat, the ridges are split out in such a way, that the space which the crown of the old ridge occupied is now allotted to the open furrow between the new ones. This is technically called *crown-and-furrow* ploughing. 2. When the soil is naturally rather wet, or, if the ridges have been raised a little by former ploughings, the form of the old ridges, and the situation of the inter-furrows, are preserved by what is called *casting*, that is, the furrows of each ridge are all laid in one direction, while those of the next adjoining ridge are turned the contrary way; two ridges being always ploughed together. 3. It is commonly necessary to raise the ridges on soils very tenacious of moisture, by what is called *gathering*, which is done by the plough going round the ridge, beginning at the crown and raising all the furrow slices inwards. 4. This last operation, when it is wished to give the land a level surface, as in fallowing, is reversed by

Crown and Furrow ploughing.

Casting.

Gathering.

Cleaving.

turning all the furrow-slices outwards; beginning at the inter-furrows, and leaving an open furrow on the crown of each ridge. In order to bring the land into as level a state as possible, the same mode of ploughing or *cleaving* as it is called, may be repeated as often as necessary.

Levelling.

High crooked ridges, which are described at some length in the body of the work, are universally disapproved of, and now very rare in the best cultivated districts. A machine employed in levelling such land is exhibited on Plate VIII. and a reward was given by the Society of Arts in London, for the improvements made on it by Mr David Charles in 1803.

Extent ploughed by two horses.

In the strongest lands, a pair of good horses ought to plough three quarters of an acre in nine hours, but upon the same land, after the first ploughing, or on friable soils, one acre, or an acre and a quarter is a common day's work. Throughout the year, an acre a day may be considered as a full average, on soils of a medium consistency. The whole series of furrows on an English statute acre, supposing each to be nine inches broad, would extend to 19,360 yards; and adding twelve yards to every 220 for the ground travelled over in turning, the whole work of one acre may be estimated as extending to 20,416 yards, or eleven miles and nearly five furlongs.

Ribbing.

A kind of ploughing known by the name of *ribbing*, was formerly common on land intended for barley, and was executed soon after harvest, as a preparation for the spring ploughings. A similar operation is still in use in some places, after land has been pulverized by clean ploughings, and is ready for receiving the seed. By this method only half the land is stirred, the furrow being laid over quite flat, and covering an equal space of the level surface. But, except in the latter instance, where corn is meant to grow in parallel lines, and where it is used as a substitute for a drill-machine, ribbing is highly objectionable, and has become almost obsolete.

Scarifying.

Various inventions, under the names of *Cultivator*, *Scarificator*, *Scuffler*, &c. have been employed in England to supply the place of the plough, or rather to diminish the number of ploughings. Their use is to loosen the soil without bringing up a new surface. One of them under the name of *a Grubber*, has been already described in the section on Implements, and an engraving of it is annexed. (See Plate I.) An implement of this kind, worked by two horses, may cover a space of three feet, and the breadth of its work is consequently equal to that of four ordinary furrows, or to four acres a day; and upon lands that are considerably pulverized, it may go over six acres. If three operations of such a machine be equal in point of efficacy to two ploughings, the saving of expence must in all cases be considerable; particularly in those districts where the plough is still worked by a team of four or six horses. But one, and, on strong land, two ploughings must be given, before it can be employed with much advantage.

### Sect. V. Fallowing.

Opinions on Fallowing.

There is no branch of agricultural practice that has engaged more attention of late than this; and after many years controversy, in which some of the ablest cultivators of the present day have entered the lists, and exhausted perhaps all the legitimate arguments on both sides, the practice does not appear to give way, but rather to extend, on wet tenacious clays; and it is only on such that any one contends for the advantages of fallowing. The expediency or inexpediency of pulverizing and cleaning the soil by a bare fallow, is a question that can be determined only by experience, and not by argument. No reasons, however ingenious, for the omission of this practice, can bring conviction to the mind of a farmer, who, in spite of all his exertions, finds, at the end of six or eight years, that his land is full of weeds, sour and comparatively unproductive. Drilled and horse-hoed green crops, though cultivated with advantage on almost every soil, are probably in general unprofitable as a *substitute* for fallow, and after a time altogether inefficient. It is not because turnips, cabbages, &c. will not grow in such soils, that a fallow is resorted to, but because, taking a course of years, the value of the successive crops is found to be so much greater, even though an unproductive year is interposed, as to induce a preference to fallowing. Horse-hoed crops, of beans in particular, postpone the recurrence of fallow, but in few situations can ever exclude it altogether.

On the other hand, the instances that have been adduced, of a profitable succession of crops on soils of this description, without the intervention of a fallow, are so well authenticated, that it would be extremely rash to assert that it can in no case be dispensed with on clay soils. Instances of this kind are to be found in different parts of Mr Young's *Annals of Agriculture;* and a very notable one, on Mr Greg's farm of Coles, in Hertfordshire, is accurately detailed in the sixth volume of the *Communications to the Board of Agriculture.*

Probable causes of this difference.

The principal causes of this extraordinary difference among men of great experience, may probably be found in the quality of the soil, or in the nature of the climate, or in both. Nothing is more vague than the names by which soils are known in different districts. Mr Greg's farm in particular, though the soil is denominated "heavy arable land," and "very heavy land," is found so suitable to turnips, that a sixth part of it is always under that crop, and these are consumed on the ground by sheep— a system of management which every farmer must know to be altogether impracticable on the wet tenacious clays of other districts. It may indeed be laid down as a criterion for determining the question, that wherever this management can be profitably adopted, fallow, as a regular branch of the course, must be not less absurd than it is injurious, both to the cultivator and to the public. It is probable, therefore, that, in debating this point, the opposite parties are not agreed about the quality of the soil; and in particular, about its property of absorbing and retaining moisture, so different in soils that in common language have the same denomination.

Another cause of difference must be found in the climate. It is well known, that a great deal more rain falls on the west than on the east coast of Britain;

Fallowing.

and that between the southern and northern counties there is at least a month or six weeks' difference, in the maturation of the crops. Though the soil therefore be as nearly as possible similar in quality and surface, the period in which it is accessible to agricultural operations, must vary accordingly. Thus, in the south-eastern counties of the island, where the crops may be all cut down, and almost all carried home by the end of August, much may be done in cleansing and pulverizing the soil, during the months of September and October, while the farmers of the north are exclusively employed in harvest work, which is frequently not finished by the beginning of November. In some districts in the south of England, wheat is rarely sown before December; whereas in the north, and still more in Scotland, if it cannot be got completed by the end of October, it must commonly be delayed till spring, or oats or barley be taken in place of wheat.

It does not then seem of any utility to enter farther into this controversy, which every skilful cultivator must determine for himself. All the crops, and all the modes of management which have been proposed as a substitute for fallow, are well known to such men, and would unquestionably have been generally adopted long ago, if, upon a careful consideration of the advantages and disadvantages on both sides, a bare fallow was found to be unprofitable in a course of years. The reader who wishes to examine the question fully, may consult, among many others, the works noted below.*

However necessary the periodical recurrence of fallow may be on retentive clays, its warmest advocates do not recommend it on turnip soils, or on any friable loams incumbent on a porous subsoil; nor is it in any case necessary every third year, according to the practice of some districts. On the best cultivated lands it seldom returns oftener than once in six or eight years, and in favourable situations for obtaining an extra supply of manure, it may be advantageously dispensed with for a still longer period.

Fallows are in many instances so grossly mismanaged, particularly where they recur so often as to make it an object to derive some profit from them by means of sheep, that it may be of use to describe the several operations, according to the justly esteemed practice of East Lothian and Berwickshire.

Fallowing described.

"Invariably after harvest, the land intended for being summer fallowed in the ensuing year, gets an end-long ploughing, which ought to be as deep as the soil will admit, even though a little of the *till* or subsoil is brought up. This both tends to deepen the cultivated or manured soil, as the fresh accession of hitherto uncultivated earth becomes afterward incorporated with the former manured soil, and greatly facilitates the separation of the roots of weeds during the ensuing fallow process, by detaching them completely from any connection with the fast subsoil. This autumnal ploughing, usually called the winter furrow, promotes the rotting of stubble and weeds; and if not accomplished towards the end of harvest, must be given in the winter months, or as early in the spring as possible. In giving this first ploughing, the old ridges should be gathered up, if practicable, as in that state they are kept dry during the winter months; but it is not uncommon to split them out or divide them, especially if the land had been previously highly gathered, so that each original ridge of land is divided into two half ridges. Sometimes, when the land is easily laid dry, the furrows of the old ridges are made the crowns of the new ones, or the land is ploughed in the way technically called *crown-and-fur*. In other instances, two ridges are ploughed together, by what is called *casting*, which has been already described. After the field is ploughed, all the inter-furrows, and those of the headlands, are carefully opened up by the plough, and are afterwards gone over effectually by a labourer with a spade, to remove all obstructions, and to open up the water furrows into the fence ditches, wherever that seems necessary, that all moisture may have a ready exit. In every place where water is expected to lodge, such as *dishes* or hollow places in the field, cross or oblique furrows are drawn by the plough, and their intersections carefully opened into each other by the spade. Wherever it appears necessary, cross cuts are also made through the head ridges into the ditches with a spade, and every possible attention is exerted, that no water may stagnate in any part of the field.

"As soon as the spring seed-time is over, the fallow land is again ploughed end-long. If formerly split, it is now ridged up; if formerly laid up in gathered ridges, it is split or cloven down. It is then cross-ploughed; and after lying till sufficiently dry to admit the harrows, it is harrowed and rolled repeatedly, and every particle of the vivacious roots of weeds brought up to view, carefully gathered by hand into heaps, and either burnt on the field or carted off to the compost midden. The fallow is then ridged up, which places it in a safe condition in the event of bad weather, and exposes a new surface to the harrows and roller; after which the weeds are again gathered by hand, but a previous harrowing is necessary. It is afterwards ploughed, harrowed, rolled, and gathered as often as may be necessary to reduce it into fine tilth, and completely to eradicate all root weeds. Between these successive operations, repeated crops of seedling weeds are brought into vegetation and destroyed. The larvæ likewise of various insects, together with an infinite variety of the seeds of weeds, are exposed to be devoured by birds, which are then the farmer's best friends, though often proscribed as his bitterest enemies.

"Some writers on husbandry have condemned the use of the harrow and roller in the fallow process, alleging, that frequent ploughing is all that is necessary to destroy root-weeds, by the baking or drying of the clods in the sun and wind; but experience has ascertained, that frequently turning over the ground,

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* Young's *Annals of Agriculture*, and his writings generally; Hunter's *Georgical Essays*; Dickson's *Practical Agriculture*; Sir H. Davy's *Agricultural Chemistry*; Brown's *Treatise on Rural Affairs*; *The County Reports*; And *The General Report of Scotland*.

Fallowing ‖ Kinds of Crops.

though absolutely necessary while the fallow process is going on, can never eradicate couch-grass or other root-weeds. In all clay soils, the ground turns up in lumps or clods, which the severest drought will not penetrate so sufficiently as to kill the included roots. When the land is again ploughed, these lumps are simply turned over and no more, and the action of the plough serves in no degree to reduce them, or at least very imperceptibly. It may be added, that these lumps likewise inclose innumerable seeds of weeds, which cannot vegetate unless brought under the influence of the sun and air near the surface. The diligent use, therefore, of the harrow and roller, followed by careful hand-picking, is indispensably necessary to the perfection of the fallow process." (*General Report of Scotland*, Vol. I. p. 419.)

When effectually reduced to fine tilth, and thoroughly cleaned from roots and weeds, the fallow is ploughed end-long into gathered ridges or lands, usually fifteen or eighteen feet broad; which are set out in the manner already described, in treating of the striking of furrows or *feiring*. If the seed is to be drilled, the lands or ridges are made of such widths as may suit the construction of the particular drill-machine that is to be employed. After the land has been once gathered by a deep furrow, proportioned to the depth of the cultivated soil, the manure is laid on, and evenly spread over the surface, whether muck, lime, marl, or compost. A second gathering is now given by the plough; and this being generally the furrow upon which the seed is sown, great care is used to plough as equal as possible. After the seed is sown and the land thoroughly harrowed, all the inter-furrows, furrows of the headlands, and oblique or *gaw* furrows are carefully opened up by the plough, and cleared out by the spade, as already mentioned, respecting the first or winter ploughing.

The expence of fallowing must appear, from what has been said, to be very considerable, when land has been allowed to become stocked with weeds; but if it be kept under regular management, corn alternating with drilled pulse or green crops, the subsequent returns of fallow will not require nearly so much labour. In common cases, from four to six ploughings are generally given, with harrowing and rolling between, as may be found necessary; and, as we have already noticed, the *cultivator* may be employed to diminish this heavy expence. But it must be considered, that upon the manner in which the fallow operations are conducted, depend not only the ensuing wheat crop, but in a great measure all the crops of the rotation.

## Sect. VI. Of the different kinds of Crops.

As this most important branch of agriculture, has been very fully treated in the body of the work, (Agriculture, Part I. Section III.) we shall here confine ourselves to a few leading observations; noticing, as we proceed, any changes that may have been recently introduced, either in the species of crops, or in the culture and general management. And for the convenience of referring to the former article, we shall adopt nearly the same arrangement.

Kinds of Crops.

### 1. *Wheat.*

Soil and preparation.

Clays and strong loams, though certainly best adapted for wheat, are not by any means the only description of soils on which it is cultivated. Before the introduction of turnips and clover, all soils but little cohesive were thought quite unfit for wheat; but, even on sandy soils, it is now grown extensively, and with much advantage after either of these crops. The greater part of the wheat crop throughout Britain, however, is probably still sown upon fallowed land. When it succeeds turnips consumed on the ground, or clover cut for hay or soiling, it is commonly sown after one ploughing; but, upon heavier soils, or after grass of two or more years, the land is ploughed twice or three times, or receives what is called a *rag-fallow*.

Varieties.

In general, the fine white wheats are considered more delicate than the brown and red, and the latter sort in particular, though seldom sown on rich warm soils, is found most profitable, from its hardiness and early ripening, on inferior soils, in an unfavourable climate. A great many different sorts of summer wheat, transmitted a few years ago to the president of the Board of Agriculture from the Agricultural Society of Paris, were divided for the purpose of experiment, among several distinguished agriculturists; * but there has not yet been time for establishing their comparative merits, or their adaptation to the climate of Britain. Summer, or, as it is often called, spring wheat, has however been long and extensively cultivated in some parts of England, particularly in Lincolnshire; and, it is probable, may be found a valuable crop in the southern counties: but the trials that have been made in the north, do not seem to entitle it to a preference over winter wheat sown in spring, or even oats or barley, in that climate.

Time of sowing.

*Winter* wheat is sown on early turnip soils, after clover or turnips, at almost every period from the beginning of September till the middle of March; but the far greater part is sown in September and October. For *summer* wheat, in the southern districts, May is sufficiently early, but in the north, the last fortnight of April is thought a more eligible seed-time. In the cultivation of spring sown winter wheat, it is of importance to use the produce of spring sown grain as seed, as the crop of such grain ripens about a fortnight earlier than when the produce of the same wheat winter sown is employed as spring seed.

Preparation of seed.

Wheat before being sown is usually prepared with *pickles* or steeps and quicklime, as a preventative against *smut*. (See Agriculture, Theory, Section VII.) This important subject having been treated in the place referred to at some length, we shall only add a short account of a method of preparation, which has been followed with success in the south of Scotland,—and of the efficacy of which we can speak from our own experience. Take four vessels, two of them smaller than the other two, the former with wire bottoms, and of a size to contain about a bushel of wheat,

* *Communications to the Board of Agriculture*, Vol. VII. p. 11.

Kinds of Crops.

the latter large enough to hold the smaller within them. Fill one of the large tubs with water, and, putting the wheat in a small one, immerse it in the water, and stir and skim off the grains that float above; and renew the water as often as is necessary, till it comes off almost quite clean. Then raise the small vessel in which the wheat is contained, and repeat the process with it in the other large tub, which is to be filled with stale urine; and in the mean time wash more wheat in the water tub. When abundance of water is at hand, this operation is by no means tedious; and the wheat is much more effectually cleansed from all impurities, and freed more completely from weak and unhealthy grains and the seeds of weeds, than can be done by the winnowing-machine. When thoroughly washed and skimmed, let it drain a little, then empty it on a clean floor, or in the cart that is to take it to the field, and riddle quicklime upon it, turning it over, and mixing it with a shovel, till it be sufficiently dry for sowing.

Broad-cast and drill sowing.

Wheat is most commonly sown *broad-cast*, in a manner too well known to need any description. Drilling is however extensively practised in some districts, and is becoming more general on lands infested with the seeds of annual weeds, especially when sown in spring. A machine which sows at three different intervals, according to the judgment of the farmer, of 12, 10½ or 9 inches, is much approved of in Scotland. It deposits six, seven, or eight rows at once, according as it is adjusted to one or other of these intervals, and the work is done with ease and accuracy when the ridges are previously laid out of such a breadth, 12½ feet, as to be sown by one *bout;* the machine going along one side of such a ridge, and returning on the other, and its direction being guided by one of its wheels, which thus always runs in the open furrow between the ridges. If the 10½ inch interval be adopted, and it is the most common one in that country, the machine sows seven rows at once, or fourteen rows on a ridge of twelve feet and a half. But the space between the rows varies in some parts still more than this machine admits of; it ought not, however, to be so narrow as to prevent hand-hoeing, even after the crop has made considerable progress in growth; and it cannot advantageously be so wide as to admit the use of any effective horse-hoe. For a fuller discussion of this subject, see the principal article, Part I. section viii.

Sowing on Ribbs.

A third mode of sowing is common in some places, by which a drill machine is dispensed with, though the same purpose is nearly answered. This is by what is called *ribbing*, which we have already adverted to in the section on tillage. The seed is scattered with the hand in the usual broad-cast manner, but as it necessarily falls for the most part in the furrows between the ribbs, the crop rises in straight parallel rows, as if it had been sown by a drill-machine; and the ribbs are afterwards levelled by harrowing across them. This plan has nearly all the advantages of drilling, in so far as regards exposure to the rays of the sun, and the circulation of air among the plants; but, as some plants must always rise between the rows, it is not quite so proper when hand-hoeing is required.

Quantity of seed.

The quantity of seed necessary, depends both on the time of sowing and the state of the land; land sown early, requiring less than the same land when sown in winter or spring, and poor land being at all times allowed more seed than the rich. The quantity accordingly varies from two bushels or less to three, and sometimes even to four bushels *per* English statute acre. Winter wheat, when sown in spring, ought always to have a liberal allowance, as the plants have not time to tiller much without unduly retarding their maturation.

After Culture.

When wheat is sown broad-cast, the subsequent culture must generally be confined to harrowing, rolling, and hand-hoeing. As grass-seeds are frequently sown in spring on winter-sown wheat, the harrows and roller are employed to loosen the soil, and cover the seeds. But these operations, to a certain extent, and at the proper season, are found beneficial to the wheat crop itself, and are sometimes performed even when grass-seeds are not to be sown. One or two courses of harrowing penetrate the crust which is formed on tenacious soils, and operate like hand-hoeing in raising a fresh mould to the stems of the young plants. Rolling in spring ought never to be omitted on dry porous soils, which are frequently left in so loose a state by the winter frosts, that the roots quit the soil and perish; and if the land be rough and cloddy, the roller has a still more beneficial effect than the harrows in pulverizing the inert masses, and extending the pasture of the plants. Hand-weeding, so far as to cut down thistles and other long weeds, is never neglected by careful farmers; but the previous culture ought to leave as little as possible of this work to be done when the crop is growing. Annual weeds, which are the most troublesome, can only be effectually destroyed by hand-hoeing; and to admit of this, the crop should be made to rise in rows, by being sown either by a drill-machine, or on ribbs. Where grass-seeds are to be sown on drilled wheat, the hand-hoeing assists in covering them.

Reaping.

Wheat, which is almost universally reaped with the sickle,* ought not to stand till it be what is called *dead* ripe, when the loss is considerable, both upon the field and in the stack-yard. When cut, it is usually tied up in sheaves, which it is better to make so small as to be done by bands the length of the straw, than so thick as to require two lengths to be joined for bands. The sheaves are set up in *shocks* or *stooks*, each containing in all twelve, or, if the straw be long, fourteen sheaves. In the latter case, two rows of six sheaves are made to stand in such a manner as to be in contact at the top, though, in order to admit the circulation of air, at some distance below, and along this line, two sheaves more are placed as a covering, the corn end of both being towards the extremities of the line. In a few days of good weather the crop

Shocks.

* In Hainault, in Flanders, a short scythe is commonly employed instead of a sickle; and this implement has been successfully tried in some places in England. See Plate IV. fig. 6. 7. 8., and the *Description* of that Plate.

Kinds of Crops.

Housing and Stacking.

is ready for the barn or stack-yard. In the stack-yard, which is commonly contiguous to the farm-offices, having the barn on one of its sides, it is built either in oblong or circular stacks, sometimes on frames supported with pillars, to prevent the access of vermin, and to secure the bottom from dampness; and as soon afterwards as possible the stacks are neatly thatched. When the harvest weather is so wet as to render it difficult to prevent the stacks from heating, it has been the practice to make funnels through them, a large one in a central and perpendicular direction, and small lateral ones to communicate with it. A particular method of constructing pillars, frames, and *bosses*, as the funnels are called, is described in a recent publication. (*Husbandry of Scotland*, Vol. I. p. 373.) In the best cultivated counties, the use of large barns for holding the crop is disapproved of, not only on account of the expence, but because corn keeps better, or is less exposed to damage of any kind, in a well-built stack.

Thrashing.

By means of the thrashing-mill, all sorts of corn are expeditiously separated from the straw, and dressed for market. One man feeds the grain in the straw into the machine, and is assisted by two half-grown lads, or young women, one of whom pitches or carries the sheaves from the bay close to the thrashing-stage, while the other opens the bands of every sheaf, and lays the sheaves successively on a small table close by the feeder, who spreads them evenly on the feeding-stage, that they may be drawn in successively by the fluted rollers, to undergo the operation of thrashing. In the opposite end of the barn, or straw-house, into which the rakes or shakers deliver the clean thrashed straw, one man forks up the straw from the floor to the *straw-mow*, and two lads, or young women, build it and tread it down. In a thrashing-machine, worked by water or wind, this is the whole expence of hand labour in the thrashing part of the operation; and, as a powerful machine can easily thrash from two to three hundred bushels of grain in a working day of nine hours, the expence is exceedingly small indeed. Assuming two hundred and fifty bushels as an average for the work of these people for one day, and their wages to be nine shillings, the expence does not amount to one halfpenny for each bushel of grain. Even reducing the quantity of grain thrashed to one hundred and fifty bushels, the easy work of a good machine of inferior size and power, the expence does not exceed three farthings the bushel. But the whole of this must not be charged against the thrashing only, the grain being half dressed at the same time, by passing through one winnowing-machine, which is always attached to a complete thrashing-mill; and where a second can be conveniently connected with it, as is commonly the case if the mill be of considerable power, the corn comes down nearly ready for market. So that the thrashing, dressing, and building of the straw, with the use of a powerful water-mill, will scarcely cost more than dressing alone when the flail is employed; after every reasonable allowance for the interest of money, and the tear and wear of the machine.

When grain is thrashed with a machine worked by horses, the expence is necessarily and considerably enhanced. One capable of effecting the larger quantity of work already calculated on, will require eight good horses, and a man to drive them, who may perhaps require the aid of a boy. The value of the work of eight horses for a day cannot be less than forty shillings, and the wages of the driver may be called two shillings and sixpence. Hence the total expence of thrashing two hundred and fifty bushels will amount to L. 2, 2s. 6d.; or about twopence *per* bushel, when the wages of the attendants are added; still leaving a considerable difference in favour of thrashing by the machine in preference to the flail. Were it even ascertained, that the expence of thrashing by horses and by the flail is nearly the same, horse-mills are to be recommended on other accounts;—such as better thrashing, expedition, little risk of pilfering, &c.



Smut.

The diseases of plants being treated in the principal article (*Theory*, Sect. vii.), we shall do little more here than notice *smut* and *mildew*, the principal diseases of wheat. Respecting the *cause* of smut, different theories have been offered, which, however ingenious and plausible, do not seem sufficiently precise to lead to any practical result. In whatever manner this disease may be transmitted from the seed pickle in the ground to the ear, it seems certain that, in general, the proximate cause of smut is the infection of the seed by the dust of the smut-ball, (*Lycoperdon globosum;*) and that, though the most careful washing, even with the application of caustics, may not in every case insure against smut, yet, if the seed be prepared in the way already mentioned, the disease will never prevail to such a degree as to affect materially the value of the crop. This is all that cultivators need to know, and all, perhaps, in the present state of science, that can be known, of the cause and prevention of smut.

Mildew.

*Mildew* is a much more destructive distemper than smut, and, as it is probably occasioned by a peculiar state of the atmosphere between the periods of flowering and ripening, it is likely to baffle all attempts at prevention. The prevalence of heavy fogs or mist, drizzling rains, and sudden changes in the temperature, have been assigned as the causes of mildew; and as it has been found, that open airy exposures are much less affected than low sheltered lands, in years when mildew prevails most generally, the disorder may perhaps be somewhat diminished by drilling, which admits a freer circulation of air. Spring or summer wheat is less liable to mildew than the winter species, though it does not always escape. Minute parasitical fungi are commonly detected on the straw of mildewed wheat; and there cannot be the least doubt that the barberry bush, and probably several other shrubs, on which these fungi abound, have a powerful influence in communicating the disease to a certain distance. (Sir Joseph Banks *on Mildew*, and *Communications to the Board of Agriculture*, Vol. VII.)

### 2. *Rye.*

Rye.

The cultivation of this species of grain is more limited than it was in former times, when rye, either by itself or mixed with wheat, furnished the bread of the labouring classes; and in most parts of Britain, there is no steady demand for it. It is, nevertheless,

Kinds of Crops. a profitable crop in particular districts, and especially on sandy soils, that will scarcely carry any other kind of grain. There are two general varieties—the one sown before winter, and the other in spring; and it is further distinguished by its black or white colour. The winter sort, which is the most plump and hardy grain, is sometimes cultivated as a green crop, to be eaten in spring, where turnips are not raised, or after they are consumed. There is nothing in its habits or mode of culture that requires particular notice. It is sometimes sown on the margins of fields, near farm-houses, as a protection to other crops against the depredations of poultry, which do not feed on it, and seldom penetrate through it; and its straw is more valuable for thatch, though useless as fodder, than that of any other species of corn.

### 3. *Barley*.

Barley,—Soil proper for. This is a much less hardy grain than either of the former, and succeeds best on a finely pulverized soil, not so little cohesive as that which will carry rye, but much farther removed, on the other hand, from the clays best adapted to the growth of wheat. It is cultivated largely as a rotation crop in several counties of England; but of late rather sparingly in Scotland, owing, it is alleged, to the present duties on malt. It is most generally sown after turnips, though sometimes after beans or peas; and even after a bare fallow, if the land be not thought fit for wheat, or if the weather has prevented it from being sown at the proper season. Spring-sown wheat, either of the winter or summer species, and early oats, particularly the potatoe variety, now occupy a large portion of the land that was formerly allotted to barley.

Varieties. The most intelligible distinction among the different kinds of barley is founded on the number of the rows on the ear. Thus, we have *Hordeum distichon*, two-rowed barley, which is the kind most extensively cultivated, and comprises several varieties; *Hordeum tetrastichon*, four-rowed barley, often called *bear* or *bigg*, the culture of which is, for the most part, confined to inferior soils, or to situations where the climate is unfavourable to the former species; and *Hordeum hexastichon*, or six-rowed barley, which is but little known in Britain, though it is the prevailing kind in the north of Europe, and said to be the hardiest of all. (See principal article, No. 261.)

Preparation. To whatever crop barley succeeds, the harrow and roller, when the plough alone is insufficient, should be employed in reducing the soil to a considerable degree of fineness. In most cases more than one earth is given; though, after a winter furrow, the *cultivator* may be used in spring instead of the plough. After turnips, eaten on the ground by sheep, the land, being consolidated by their treading, sometimes receives two ploughings; but if only one, it should be well harrowed and rolled; and it is often finished by harrowing after the roller, especially if grass-seeds be sown, which are covered by this last harrowing. Barley is sometimes sown on the first ploughing, and covered by a second shallow ploughing. (See principal article.) As it is found of great importance, with a view to speedy and equal vegetation, that the ground should be fresh and moist, barley is generally sown upon what is termed *hot-fur*, that is, as soon as possible after it is turned up by the plough.

Season of Sowing. From the beginning of April to the middle of May is considered the best season for sowing barley; though in early situations it may be sown a fortnight later. *Bear*, or *bigg*, is an earlier, as well as a hardier kind, than the two-rowed barley, and may be sown later. Winter sown barley, which may be eaten in spring and afterwards stand for a crop, is found to answer well in particular districts. On land infested with annual weeds, the drilling of this grain is an advantageous practice; but throughout the country at large, this, and all other culmiferous crops, are more generally sown *broad-cast*. If the land be rich, a small quantity of seed is sufficient; often so little as two bushels per acre, and seldom more than three, or three and a half.

Reaping. Barley is cut down in some places with the sickle, and in others with the scythe; in England, very commonly with the latter, and in Scotland almost always with the former. It is the most difficult of all the species of corn to save in a precarious harvest, and usually requires more labour in thrashing and dressing, particularly in separating the *awns* from the grain, for which an apparatus, called a *hummelling-machine*, is frequently added to the thrashing-mill.

### 4. *Oats*.

Oats. This hardy grain is sown, with little preparation, on almost every kind of soil, and too often follows culmiferous crops, as well as pulse, herbage, and bulbous-rooted plants. Where a correct course of alternate white and green crops prevails, oats usually succeed clover; and it is almost always the first crop on land that has been several years in grass. As it prospers best on a soil not too finely pulverized, it is commonly sown on one earth.

Varieties. There are numerous varieties of this species, which are distinguished by colour, form, and the period of ripening; and by the names of the countries, such as the Poland and the Dutch, from whence they are understood to have been brought, or of the places where they were originally cultivated. The chief of these are the common white variety, so well known as to need no description; the red; and what is called the potatoe-oat. For land in good cultivation, the two latter are probably the best,—the red for uplands exposed to high winds,—and the potatoe variety in lower situations. Both of these are early, and yield more abundantly, in grain as well as meal, than most others. The potatoe-oat has been but recently introduced into cultivation, having been discovered by accident in Cumberland in 1788. (*Farmer's Magazine*, Vol. XIV. p. 167.) But it is now almost the only kind raised, on suitable soils, in the north of England, and throughout the lowlands of Scotland. It usually brings a higher price at Mark-lane than any other variety. The red oat is so called from the colour of its husk; it has a thinner and more flexible stem, and the grain is more firmly attached to it, than in any of the early varieties; so that upon good soils, in high situations, as it is in less danger of suffering from wind, and is, at the same time, so much earlier than the common kinds, it is entitled to a decided preference, particularly in a

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late climate. It is understood to have originated in the county of Peebles, and is sometimes called the *Magbiehill-oat*, from the name of the estate where it was first cultivated.

Season of Sowing

Oats are sown, usually *broad-cast*, in the months of March and April; seldom earlier or later, and from four to six bushels are allowed for an acre. They are often carried to the barn like hay, without being tied up in sheaves; but in the North, they are either managed in the way already described for wheat, or set up in single sheaves, or *gaits*, as they are cut, and tied more tightly when ready to be carried; and then built in the stack-yard. Wherever a thrashing-mill is employed, as it is necessary, in order to have the work done well, that corn should be presented to the rollers in a regular, uniform manner, the practice of mowing, and carrying it in a loose state, is highly inproper; and, independent of this objection, the season often occasions much damage to corn managed in this slovenly manner, which it would have escaped in sheaves and covered shocks.

Value of Straw as Fodder.

The straw of oats is of more value as fodder than that of any other corn crop, and it is advantageously used as a substitute for hay during the winter months in some of the best cultivated districts, both for farm-horses and cattle.

### 5. *Peas and Beans.*

Peas and Beans.

Respecting the first of these crops, little needs be added to what has been stated in the body of the work. Since the introduction of clover and turnips, the culture of peas, which are almost everywhere a most precarious crop, has been greatly diminished. Their straw, or haulm, is sometimes more valuable than the grain produce, which, in a wet or late season, is frequently little more than the seed; and when the straw is not luxuriant, so much of the land is left to the growth of weeds, that it is rendered unfit for carrying corn crops till cleansed by a fallow or fallow crop. Drilling is but an ineffectual remedy for these inconveniences, the stems falling over and covering the ground in so irregular a manner, as, in a great measure, to prevent either horse or hand hoeing, at the time when it would be most beneficial. Yet a luxuriant crop of peas, by completly covering the surface, keeping the soil in a moist and mellow state, and preventing the growth of weeds, is a good preparation for both wheat and barley.

The cultivation of beans is almost confined to clays and strong loams, in the best managed districts; turnip soils being by no means suited to this crop. Beans usually succeed wheat or oats, but sometimes also clover or pasture grass. The common horse-bean is the kind most generally cultivated; but large and small *ticks* are preferred in some of the English counties.

Modes of Sowing.

Beans, though still sown *broad-cast* in several places, and sometimes *dibbled*, are, for the most part, drilled by judicious cultivators, or deposited after the plough in every furrow, or only in every second or third furrow. In the latter method, the crop rises in rows, at regular intervals of 9, 18, or 27 inches, and the hand-hoe ought invariably to be employed; but it is only where the widest interval is adopted, that the horse-hoe can be used with much effect in their subsequent culture.

Preparatory Culture for Beans.

In the preparation of the land, much depends on the nature of the soil and the state of the weather; for as beans must be sown early in the spring, it is sometimes impossible to give it all the labour which a careful farmer would wish to bestow. It must also be regulated, in some measure, by the manner of sowing. But as we are decidedly of opinion, that beans ought, in general, to be planted with such a distance between the rows, as to admit of horse-hoeing, we shall confine ourselves to this mode of culture, which we think should be generally known; making use of the latest publication on the subject, which contains an accurate account of the different operations. (*General Report of Scotland*, Vol. I. p. 515.)

In preparing ground for beans, it ought to be ploughed with a deep furrow after harvest, or early in winter; and as two ploughings in spring are highly advantageous, the winter-furrow may be given in the direction of the former ridges, in which way the land is sooner dry in spring than if it had been ploughed across. The second ploughing is to be given across the ridges, as early in spring as the ground is sufficiently dry; and the third furrow either forms the drills, or receives the seed, as shall be mentioned immediately.

Dung is often applied to the bean crop, especially if it succeeds wheat. By some, dung is spread on the stubble previous to the winter ploughing; but this cannot always be done in a satisfactory manner, at least in the northern parts of the island, unless during frost, when it may lie long exposed to the weather before it can be turned down by the plough. The most desirable mode therefore is, to lay the manure into drills immediately before the beans are sown.

Sowing in Rows.

There are, as already hinted, two several modes of drilling beans. In one of these, the lands, or ridges, are divided by the plough into ridgelets, or *one bout* stitches, at intervals of about 27 inches. If dung is to be applied, the seed ought to be first deposited, as it is found inconvenient to run the drill-machine afterwards. The dung may then be drawn out from the carts in small heaps, one row of heaps serving for three or five ridgelets; and it is evenly spread, and equally divided among them, in a way that will be more minutely described when treating of the culture of turnips. The ridgelets are next split out or reversed, either by means of the common plough, or one with two mould-boards, which covers both the seed and the manure in the most perfect manner.

When beans are sown by the other method, in the bottom of a common furrow, the dung must be previously spread over the surface of the winter or spring ploughing. Three ploughs then start in succession one immediately behind another, and a drill barrow either follows the third plough, or is attached to it, by which the beans are sown in every third furrow, or at from 24 to 27 inches asunder, according to the breadth of the furrow-slice.

Another approved way of sowing beans, when dung is applied at seed-time, is to spread the dung,

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and to plough it down with a strong furrow; after which shallow furrows are drawn, into which the seed is deposited by the drill-machine. Whichever of these modes of sowing is followed, the whole field must be carefully laid dry by means of channels formed by the plough, and when necessary by the shovel; for neither then nor at any former period should water be allowed to stagnate on the land.

Time of Sowing.

The time of sowing beans is as early as possible after the severity of winter is over; in the south sometimes in January, but never later than the end of March; as the ripening of the crop and its safe harvesting would otherwise be very precarious in this climate.

Quantity of Seed.

The quantity of seed allowed is very different in the southern and northern parts of Britain; in the former, even when the rows are narrow, only two bushels or two bushels and a half; but in Scotland seldom less than four bushels to the English statute acre, even when sown in ridgelets 27 inches distant, and a bushel more when sown *broad-cast*.

Beans and Peas mixed.

Both in the broad-cast and drill husbandry, it is common to mix a small quantity of peas along with beans. This mixture improves both the quantity and quality of the straw for fodder, and the peas-straw is useful for binding up the sheaves in harvest.

After Culture.

The bean crop is generally harrowed to destroy annual weeds, sometimes just before the plants make their appearance, and sometimes after the beans have got their first green leaves, and are fairly above ground. When sown in rows, in either of the modes already mentioned, the harrows are employed about ten or twelve days after; and, being driven across the ridgelets, the land is laid completely level for the subsequent operations.

After the beans have made some growth, sooner or later according as the soil may happen to be encumbered with or free from weeds, the horse-hoe is employed in the interval between the rows; and followed by the hand-hoe for the purpose of cutting down such weeds as the horse-hoe cannot reach; all the weeds, that grow among the beans beyond the reach of either hoe, should be pulled up with the hand. The same operations are repeated as often as the condition of the land in regard to cleanness may require.

Before the introduction of the horse-hoe, which merely stirs the soil, and cuts up the weeds, a common small plough, drawn by one horse, was used in working between the rows, and is still necessary where root weeds abound. This plough goes one bout, or up and down in each interval, turning the earth from the beans, and forming a ridgelet in the middle; then hand-hoes are immediately employed; and after some time, a second hand-hoeing succeeds to destroy any fresh growth of weeds. The same plough, with an additional mould-board, finally splits open the intermediate ridgelet, and lays up the earth to the roots of the beans on each side. The benefit of laying up the earth in this manner, however, is alleged to be counterbalanced by the trouble which it occasions in harvest, when it is difficult to get the reapers to cut low enough, and may be properly dispensed with, unless the soil be very wet and level.

Reaping.

In an early harvest, and when the straw is not immoderately rank, the bean crop becomes ripe in good time, and is easily prepared for the stack-yard. But in moist warm seasons, the grain hardly ever ripens effectually; and it is exceeding difficult to get the straw into a proper condition for the stack. In such cases, it has been found of advantage to switch off the succulent tops with an old scythe blade set in a wooden handle, with which one man can easily top-dress two acres a-day. This operation, it is said, will occasion the crop to be ready for reaping a fortnight earlier, and also perhaps a week sooner ready for the stack-yard after being reaped. In order to have the land prepared for a wheat crop, beans are sometimes removed from the ground, and set up to dry in another field.

The most approved mode of reaping beans is with the sickle, but they are sometimes mown, and in a few instances even pulled up by the roots. They should be cut as near the ground as possible, for the sake of the straw, which is of considerable value as fodder, and because the best pods are often placed on the stems near the roots. They are then left for a few days to wither, and afterwards bound and set up in shocks to dry, but without any head-sheaves.

Beans are built in circular or oblong stacks, often in the latter form; and it is always proper, if the stack be large, to construct one or more funnels to allow a free circulation of air. They may be thrashed by the mill, and dressed by the winnowing machine like any other grain.

### 6. *Tares*.

Tares, Varieties.

The tare, though cultivated for its stems and leaves, rather than for its fruit or seeds, is so similar to the pea in its habits and mode of culture, that it seems proper to mention it in this place.

The common tare is distinguished into two sorts, the *winter* and *spring* tare. It is the opinion of an eminent botanist, that they are the same plant; (Walker's *Hebrides*, Vol. I. p. 228.); but though this may have been true of the tare in its natural state, there is reason to believe that a material difference now exists, superinduced perhaps by cultivation. (*Annals of Agriculture*, Vol. II.) The winter tare, by the experiments detailed in the work just referred to, escaped injury from frosts which destroyed the spring variety. The difference in the colour and size of the seeds is, however, so inconsiderable, as to be scarcely distinguished; but "the winter tare vegetates with a seed leaf of a fresh green colour, whereas the spring tare comes up with a grassy spear of a brown dusky hue." (Dickson's *Practical Agriculture*, Vol. II. p. 889.)

Season of Sowing.

The winter variety is sown in September and October, and the first sowing in spring ought to be as early as the season will permit. If they are to be cut green for soiling throughout the summer and autumn, which is the most advantageous method of consuming them, successive sowings should follow till the end of May. The quantity of seed to an acre is from $2\frac{1}{2}$ to $3\frac{1}{2}$ bushels, according to the time of sowing, and as they are to be consumed green or left to stand for a crop.

Sometimes eaten on the ground.

Tares are in some places eaten on the ground by

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different kinds of live stock, particularly by sheep; and as the winter sown variety comes very early in spring, the value of this rich food is then very considerable. The waste, however, in this way, even though the sheep be confined in hurdles, must be great: and still greater when consumed by horses or cattle. But if the plants be cut green, and given to live stock either on the field, or in the fold-yards, there is, perhaps, no green crop of greater value, nor any better calculated to give a succession of herbage from May to November. The winter sown tare, in a favourable climate, is ready for cutting before clover; the first spring crop comes in after the clover must be all consumed or made into hay; and the successive spring sowings give a produce more nourishing for the larger animals than the aftermath of clover, and may afford green food at least a month longer.

Mixed with rye and oats.

A little rye sown with winter tares, and a few oats with the spring sort, not only serve to support the weak creeping stems of the tares, but add to the bulk of the crop by growing up through the interstices.

Culture.

There is little difference in the culture of tares and of peas; they are often sown broad-cast, but sometimes in rows, with intervals to admit of hand-hoeing. The land ought to be rolled as a preparation for mowing; and they should always be cut with the scythe, rather than with a sickle, which, by tearing up a number of the plants by the roots, renders the second growth of little or no value. When cut with the scythe, even an early spring sown crop sometimes yields a weighty after-crop.

Turnips or fallow the same year.

In those districts where winter sown tares are found to succeed, which is not the case in the north, the ground may be cleared in time for being sown with turnips, or dressed like a fallow for wheat to be sown in autumn.

### 7. *Potatoes.*

Potatoes.

To the observations that have been submitted on the varieties and different modes of cultivating this invaluable root, in the principal article, (No. 284), we shall only add a short account of the present most approved method.

Preparation of the soil.

In preparing land for potatoes, it is of much importance to free it as completely as possible from weed roots, which cannot be so well extirpated afterwards, as in the culture of turnips, and some other drilled crops, both because the horse hoe must be excluded altogether at a time when vegetation is still vigorous, and because at no period of their growth is it safe to work so near the plants, especially after they have made some progress in growth. It is the earlier time of planting, and of finishing the after culture, that renders potatoes a very indifferent substitute for fallow, and in this respect, in no degree comparable to turnips. For this reason, as well as on account of the great quantity of manure required, their small value at a distance from large towns, and the great expence of transporting so bulky a commodity, the culture of potatoes is by no means extensive in the best managed districts. Unless in the immediate vicinity of such towns, or in very populous manufacturing counties, potatoes do not constitute a regular rotation crop, though they are raised almost everywhere to the extent required for the consumption of the farmer and his servants, and, in some cases, for occasionally feeding horses and cattle, particularly late in spring.

The first ploughing is given soon after harvest, and a second, and commonly a third, early in spring; the land is then laid up into ridgelets, from 27 to 30 inches broad, as for turnips, and manured in the same manner; and the sets are planted at from four to eight inches distant, in April, or till the middle of May, and the ridgelets reversed to cover them. In this state the land remains till the plants begin to rise above the surface, when it is harrowed across; and afterwards the horse-hoe, or small hoeing-plough, and the hand-hoe, are repeatedly employed in the intervals, and between the plants, as long as the progress of the crop will permit, or the state of the soil may require. The earth is then gathered once, or oftener, from the middle of the intervals towards the roots of the plants, after which any weeds that may be left must be drawn out by hand; for when the radicles have extended far in search of food, and the young roots begin to form, neither the horse nor hand hoe can be admitted without injury.

Planting and culture.

Gathering the crop.

Potatoes are usually taken up by the common plough, but sometimes with three pronged forks; the plough goes twice along each ridgelet, in such a manner as not materially to injure any of the roots with its share or coulter, and the potatoes are gathered by women and children placed along the line, at proper distances. When the land is somewhat moist, or of a tenacious quality, the furrow-slice does not give out the roots freely, and a harrow which follows the plough is commonly employed to break it and separate them from the mould. Various contrivances have been resorted to for this purpose; a circular harrow or brake to be attached to the plough, of very recent invention, (See Plate III. Fig. 6.) has been found to answer the purpose well, and to effect a considerable saving of labour.

Improvements suggested.

Various suggestions have been offered for the purpose of improving the cultivation of this root. Instead of cutting the roots to be planted into sets, some have recommended the planting of them whole, and others have thought that a great saving of the root might be made by scooping out the setts. (See Plate VIII.) Several experiments have been made to augment the produce and accelerate the ripening of potatoes, by plucking off the blossoms from the *shaws* or haulm. But none of these innovations have yet entered into general practice, and the trials have not been so numerous nor so satisfactory as to warrant any conclusions of real utility.

Preservation through winter.

The potatoe crop is preserved through winter, sometimes in houses, but more generally perhaps in some convenient place near the farm buildings, in *camps*, *pies*, or *pits*, covered first with straw, and then with earth dug up around the heaps, in the form of a trench, which discharges any water that might otherwise lodge about the bottoms.

Curled tops are the most destructive disease to which this crop is liable; for a particular account of which, and the various modes of prevention that have been tried, see the principal Article, No 113.

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### 8 *Turnips.*

Turnips.

Turnips and clover are the two main pillars of the best courses of British husbandry; they have contributed more to preserve and augment the fertility of the soil for producing grain—to enlarge and improve our breeds of cattle and sheep—and to afford a regular supply of butcher's meat all the year, than any other crops; and they will probably be long found vastly superior, for extensive cultivation, to any of the rivals which have often been opposed to them in particular situations.

Soils.

Turnips cannot be advantageously cultivated on wet tenacious clays, but are grown on all comparatively dry soils, under all the variations of our climate. On dry loams, and all soils of a looser texture, managed according to the best courses of cropping, they enter into the rotation to the extent of a fourth, a sixth, or an eighth part of the land in tillage; and even on clayey soils, they are frequently cultivated, though on a smaller scale, to be eaten by cattle, for the purpose of augmenting and enriching the manure, into which the straw of corn is converted.

Drill Culture of Scotland.

After what has been said in the principal Article, it will be sufficient in this place to describe the practices of the best managed counties of Scotland, in regard to the culture of turnips. In this country broad-cast sowing is almost unknown, turnips being universally raised in rows at such a distance as to admit of horse-hoeing, and every step of the process is conducted with much accuracy and success.

The varieties commonly cultivated by the best farmers are the *white globe*, which comes early and gives a very weighty crop, but often suffers much from the frosts of winter; the *yellow*, which is more hardy and answers well for succeeding the *globe* in spring; and the *ruta baga* or *Swedish*, which may be preserved for consumption till the end of May.

The drill culture of turnips was first firmly established in Scotland, by the practice of Mr William Dawson, a farmer at Frogden, in the county of Roxburgh, soon after his entry to that farm in 1759. Turnips had been sown indeed on narrow ridges, according to the practice of Tull, many years before that period; but chiefly by proprietors, upon a very small scale; and the several operations were neither so correct, so uniform, nor so much simplified as to induce general imitation. The first person who ever formed turnip ridges in Scotland with a two-horse plough without a driver, was instructed by Mr Dawson, and is yet alive.

Preparation of the Soil.

In the drill culture of turnips, the land is ploughed with a deep furrow soon after harvest, usually in the direction of the former ridges, though, if the soil be dry, it is of little consequence in what direction. As soon as the spring seed-time is over, a second ploughing is given across the former, and the harrows and, if necessary, the rollers, are then set to work to clean and pulverize the soil. All the weed-roots that are brought to the surface are carefully gathered into heaps, and either burnt on the ground, or carried off to form a compost, usually with lime. The land is then generally ploughed a third time, again harrowed well, sometimes also rolled, and the weed-roots picked out as before. Unless land is in a much worse state, in regard to cleanness and pulverization, than it usually is after turnips have been sometime a rotation crop, no more ploughings are necessary. It is next laid up in ridgelets from 27 to 30 inches wide, either with the common swing-plough, or one with two mould-boards, which forms two sides of a ridgelet at once. Well rotted dung, at the rate of 12 or 15 tons per acre, is then carried to the field, and dropt from the cart in the middle one of three intervals, in such a quantity as may serve for that and the interval on each side of it. The dung is then divided equally among the three, by a person who goes before the spreaders, one of whom for each interval spreads it with a small three-pronged fork along the bottom. The plough immediately follows, and, reversing the ridgelets, forms new ones over the dung; and the drill-barrow, commonly one that sows two drills at once, drawn by one horse, deposits the seed as fast as the new drills are formed. This drill machine is usually furnished with two small rollers; one that goes before the sowing apparatus, and levels the pointed tops of the ridgelets, and another that follows for the purpose of compressing the soil and covering the seed. From the time the dung is carted to the ground, until the seed is deposited, the several operations should go on simultaneously; the dung is never allowed to lie uncovered to be dried by the sun and the wind; and the new ridgelets are sown as soon as formed, that the seed may find moisture to accelerate its vegetation.

Manuring. Sowing.

Time of Sowing.

The time of sowing the several varieties is somewhat different; the *Swedish* should be put in the earliest, and then the *yellow*,—both of them in the month of May. But as these kinds are much less extensively cultivated than the *globe*, the month of June is the principal seed-time; and after the first week of July a full crop is not to be expected in the northern parts of the island. The quantity of seed most commonly allowed is two pounds to the acre, which though much more than sufficient to stock the ground with plants, is thought to be necessary for insuring a regular crop on most soils. The supernumerary plants are easily taken out by the hoe, but if any parts are missed they can be filled up only by inserting a few Swedish plants; the other varieties seldom succeed after transplantation.

Culture while growing.

As soon as the plants have put forth the *rough leaf*, or sooner if annual weeds have got the start of them, a horse-hoe is run between the ridgelets and cuts up the weeds on each side, almost close to the rows of the turnip plants, clearing out the bottom of the interval at the same time. The hand-hoers are always set to work as soon as possible after, and the plants are left about nine inches distant—the Swedish kind somewhat closer. If the ground has been well prepared, and the plants not allowed to get too large, three experienced hoers go over an acre a day. A few days after this, a small swing-plough, drawn by one horse, enters the interval between the rows, and, taking a furrowslice off each side, forms a smaller ridgelet in the middle. If the annuals still rise in great abundance, the horse-hoe may be employed again, otherwise the next operation is to go over

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them a second time with the hand-hoe, when the intermediate ridgelet is levelled. Sometimes a third hoeing must be given, but that is done very expeditiously. When no more manual labour is required, a small plough with two mould-boards is employed to lay up the earth to the sides of the plants, leaving the ridgelets of the same form as when sown, which finishes the process. Large fields throughout their whole extent, dressed in this manner, are left as clean and as pleasant to the eye as the best cultivated garden. The horse and hand-hoeing in ordinary cases may cost about fifteen shillings per acre.

Where the soil is perfectly dry, and has been well prepared, the small plough has of late been laid aside by many farmers, and the space between the rows is kept clean by the horse and hand-hoe alone; but if the soil be either wet from springs, or so flat as not easily to part with surface water, it is still considered proper to earth up the roots as the concluding part of the process; and it is always useful to plough between the ridges when couch-grass and other weeds have not been completely picked out before the land was sown.

The gathering of the weeds, the spreading of the dung, and the hand-hoeing, are almost always performed by women and boys and girls.

Weight of Crop.

A good crop of white globe turnips usually weighs from 25 to 30 tons per acre, the yellow and Swedish commonly a few tons less. Of late there have been instances of much heavier crops, and in Ayrshire, it would appear, that above sixty tons have been raised on an English acre, the leaves not included. (*Farmer's Magazine*, Vol. XV. and XVI.) But such an extraordinary produce must have been obtained by the application of more manure than can be provided, without injustice to other crops, from the home resources of a farm; and where turnips form a regular crop in the rotation, no such produce is to be expected under any mode of culture.

Consumption.

Turnips are consumed either on the spot where they grow, on grass fields, in fold-yards, or in feeding-houses; the far greater part, wherever they are extensively cultivated, by sheep. The price per acre when sold depends not only upon the weight of the crop, but also on the mode of its consumption.

When eat by sheep in the place of their growth, turnips are lotted off, by means of hurdles or nets, that they may be regularly consumed. When the first allowance is nearly eaten up, the bottoms or shells are picked out of the ground, by means of a two-pronged blunt hook adapted to the purpose; and then another portion of the field is taken in, by shifting the hurdles or nets, and so on regularly until the whole are finished; the cleared part of the field being usually left accessible as a drier bed for the sheep, and that they may pick up what shells remained when a new portion of the field was taken in.

The turnips required for other modes of consumption are usually drawn out, at regular intervals, before the sheep are put upon the field; unless the soil be so poor as to need all the benefit of their dung and treading, in which case, the whole are consumed where they grow; or so rich as to endanger the succeeding crops, by eating any part of the turnips on the ground. In the latter very rare instance, the whole crop is carried to be consumed elsewhere, as must always be done, if the soil be naturally too wet for sheep feeding.

In wet weather, when sheep ought not to be allowed to lie on the turnip field, it becomes necessary to carry the turnips to a grass field; and store sheep, not requiring to be so highly fed, frequently eat their turnips on such fields, as well as rearing cattle, and sometimes milk cows. A grass field contiguous to the turnip one is always very desirable, that the sheep, confined on other sides by hurdles or nets, may always find a dry place to lie on.

In the expenditure of turnips to young cattle, and to sheep in their first year towards spring, when the loosening and shedding of their teeth render them unable to break the hard roots, it is usual to cut or slice the turnip, either by means of a spade or chopping-knife, or by an implement constructed for the purpose, called a turnip-slicer, formerly mentioned; or they are crushed by means of a heavy wooden mallet.

During severe frosts, turnips become so hard that no animal is able to bite them. The best remedy in this case is, to lay them for some time in running water, which effectually thaws them; or, in close feeding-houses, the turnips intended for next day's use may be stored up over night, in one end of the building, and the warmth of the animals will thaw them sufficiently before morning. But in those months when frosts are usually most severe, it is advisable to have always a few days' consumption in the turnip-barn formerly mentioned. When a severe frost continues long, or if the ground be covered deep with snow, potatoes ought to be employed as a substitute.

The advantages of eating turnips on the place of their growth by sheep, both in manuring and consolidating the ground, are sufficiently well known to every farmer. One great defect of the inferior sort of turnip soils is the want of tenacity; and it is found, that valuable crops of wheat may be obtained upon very light porous soils, after turnips so consumed.

Value.

The value or price by the acre is so various, from differences in soil and seasons, and fluctuates so much according to the degree of abundance and demand, that nothing can be decisively stated on this subject. It likewise varies according to the modes of application, as above noticed. A farmer who has turnips to sell will demand more money *per* acre, if they are to be drawn and consumed by the purchaser in the fold-yard, or on the pastures of the farm, than if eaten by sheep where they grow; and will require a much higher price if they are to be led away from the farm. Indeed, hardly any price will compensate for such abstraction of manure, and consequent loss of future fertility, unless where manure can be readily purchased to supply the defalcation; and that can only be done by those who are situated near towns and large villages, where a few turnips may be sold in that way for the cows of the inhabitants. Eight guineas an acre is considered a good price, in seasons of uncommon demand, for a full crop; five guineas in ordinary years; and down to thirty and forty shil-

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lings for inferior crops. Upon an average of years, five guineas may be reckoned a fair price for a good crop, eaten by sheep where they grow. Near large towns, where turnips are in demand by cowfeeders, they will sell in ordinary years for double, and when in extraordinary demand, for three, or even four times these prices; but in these cases they are always removed from the farm, and consequently, the manure which they produce is lost to the soil.

Price *per* Week.

It is not uncommon to let turnips at an agreed price, or board, for each sheep or beast weekly. This varies according to age and size, and the state of the demand, from fourpence or less to eightpence or more for each sheep weekly, and from two shillings to five for each beast. An acre of good turnips, say thirty tons, with straw, will fatten an ox of sixty stone, or ten Leicester sheep. Supposing the turnips worth six guineas, this may bring the weekly keep of the ox to six shillings and threepence halfpenny, and of the sheep to about sevenpence halfpenny, a-week. In this way of letting, however, disputes may arise, as the taker may not be careful to have them eaten up clean.

The person who lets the turnips has to maintain a herd for the taker; and when let for cattle, and consequently to be carried off, the taker finds a man and horse, and the latter maintains both. The taker has to provide hurdles or nets for fencing the allotments to sheep; but the letter must fence his own hedges if necessary. The period at which the taker is to consume the whole is usually fixed in the agreement, that the letter may be enabled to plough and sow his land in proper season.

Storing.

Common turnips are seldom stored in any great quantity, though sometimes a portion is drawn and formed into heaps, like potatoe camps, and lightly covered with straw, or preserved for some time under a shed. On these occasions, the shaws or leaves, and the tap-roots, must be cut off and removed before storing up, to prevent heating and rotting. The heaps must not be covered with earth like potatoes, for, in this case, their complete destruction is inevitable. This root contains too much water to be preserved for any length of time in a fresh and palatable state, after being removed from the ground; and though the loss in seasons unusually severe, particularly in the *white globe* variety, is commonly very great, it is probable that a regular system of storing the whole, or the greater part of the crop every season, would, upon an average of years, be attended with still greater loss; besides, the labour and expence, where turnips are cultivated extensively, would be intolerable.

Diseases.

Besides the damage sustained by a turnip crop from beetles and other insects, (see principal article), a very destructive disease, formerly confined to particular districts, has lately begun to extend itself in an alarming manner; and there is reason to fear, if some means of prevention be not soon discovered, that it may almost put an end to the cultivation of this root, in some situations where it is of essential importance, both with a view to the produce of grain, and to the rearing and fattening of live stock. In Holderness it is known by the quaint name of *fingers and toes*, from the shapes into which the disease distorts either the bulb or tap-root, or frequently both. An ingenious paper on this subject was read to the Holderness Agricultural Society, in 1811, by Mr William Spence, their present President, from which we shall abstract some account of this hitherto local disease.

Fingers and Toes.

In some plants, the bulb itself is split into several finger-diverging lobes. More frequently the bulb is externally tolerably perfect, and the tap-root is the part principally diseased; being either wholly metamorphosed into a sort of misshapen secondary bulb, often larger than the real bulb, and closely attached to it, or having excrescences of various shapes, frequently not unlike human toes, (whence the name of the disease,) either springing immediately from its sides, or from the fibrous roots that issue from it. In this last case, each fibre often swells into several knobs, so as distantly to resemble the wire and accompanying tubers of a potatoe; and not seldom one turnip will exhibit a combination of all these different forms of the disease. These distortions manifest themselves at a very early stage of the turnip's growth; and plants, scarcely in the rough leaf, will exhibit excrescences, which differ in nothing else than size from those of the full-grown root.

The leaves discover no unusual appearance, except that, in hot weather, they become flaccid and droop; from which symptom, the presence of the disease may be surmised without examining the roots. These continue to grow for some months, but without attaining any considerable size, the excrescences enlarging at the same time. If divided at this period with a knife, both the bulb and the excrescences are found to be perfectly solid, and internally to differ little in appearance from a healthy root, except that they are of a more *mealy* and less compact consistence, and are interspersed with more numerous and larger sap-vessels. The taste, too, is more acrid; and, on this account, sheep neglect the diseased plants. Towards the approach of autumn, the roots, in proportion as they are more or less diseased, become gangrenous and rot, and are either broken (as frequently happens) by high winds, or gradually dissolved by the rain. Some, which have been partially diseased, survive the winter; but of the rest, at this period, no other vestige remains than the vacant patches which they occupied at their first appearance.

This disease, according to Mr Spence, is not owing to the seed, nor to the time of sowing, nor to any quality of the soil, either original, or induced by any particular mode of cropping or of tillage; and he adds, "That the most attentive and unbiassed consideration of the facts has led him to infer that the disease, though not produced by any insect that has yet been discovered, is yet caused by some unobserved species, which, either biting the turnip in the earliest stage of its growth, or insinuating its egg into it, infuses, at the same time, into the wound a liquid, which communicates to the sap-vessels a morbid action, causing them to form the excrescences in question."

With regard to the prevention of this disease, marl has been recommended by Sir Joseph Banks and others; and where marl cannot be procured, it has been thought that an addition of mould of any kind,

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that has not borne turnips, will be advantageous;—such as a dressing taken from banks, headlands, ditches, &c. and mixed up with a good dose of lime. But lime alone has been tried in vain; and no great dependence can be placed upon fresh mould, as this disease has been known to prevail upon lands that had scarcely ever before borne a crop of turnips. (*Farmer's Magazine*, Vol. XIII.)

9. *Carrots.*

Carrots.

This crop, it is well known, requires a deep soil, inclining to sand; and cannot, therefore, be so generally cultivated as turnips. But it has been too much neglected on lands where it would have yielded a more valuable product, perhaps, than any bulbous or tap-rooted plant whatever. Several contradictory experiments in its culture have been detailed in a number of publications, from which the practical husbandman will be at a loss to draw any definite conclusion. But, in a recent communication to the Board of Agriculture, from Mr Robert Burrows, an intelligent Norfolk farmer, who has cultivated carrots on a large scale, and with great success, for several years, so accurate an account is presented of the culture, application, and extraordinary value of this root, that carrots will probably soon enter more largely into the rotation of crops on suitable soils. We shall give the substance of this communication in his own words.

Culture.

"As I think it the duty of every individual to give publicity to any invention, discovery, or practice, that carries with it the appearance of being useful to society, I shall, before I proceed to a statement of each year's culture and consumption of my carrot crops, submit to the Board, for their information, a few observations upon the general method I pursue in the cultivation of them, together with such other matter as will necessarily mingle therewith; beginning first with the quantity sown *per* acre, and the method of preparing the same.

Quantity of Seed.

"I usually sow seed of my own growth, from eight to ten pounds *per* acre; if purchased, the price is in general from one shilling to one shilling and sixpence *per* pound. By sowing seed of my own growing, I am enabled to speak both to the nature of its stock, and likewise its quality in regard to newness. The latter circumstance is of particular consequence in obtaining a full and healthy plant, and not always to be guarded against, if the seed is purchased of the seedsman. Having weighed the quantity of seed to be sown, and collected sand or fine mould, in the proportion of about two bushels to an acre, I mix the seed with the sand or mould, eight or ten pounds to every two bushels, and this is done about a fortnight or three weeks before the time I intend sowing; taking care to have the heaps turned over every day, sprinkling the outside of them with water each time of turning over, that every part of the sand heaps may be equally moist, and that vegetation may take place alike throughout. During this time, the land is preparing with a good dressing of manure, of about sixteen cart-loads *per* acre of rotten farm-yard manure, or cottagers' ashes; the load about as much as three able horses can draw, and, if bought, costs about four shillings and sixpence *per* load, besides the

Mixed with Sand before Sowing.



carting on the land. I usually sow my wheat stubbles after clover; plough the first time in autumn, and once more in the early part of the month of February, if the weather permits: setting on the manure at the time of sowing, which is about the last week in March, or sometimes as late as the second week in April; but have generally found early-sown crops the most productive. I have great advantage in preparing the seed so long before-hand; it is by this means in a state of forward vegetation, therefore lies but a short time in the ground, and, by quickly appearing above ground, is more able to contend with those numerous tribes of weeds in the soil, whose seeds are of quicker vegetation.

Time of Sowing.

"Within about five or six weeks, the carrots are ready to hoe; and, upon an average of six years, on a light sandy loam, they have cost me L. 1, 10s. 8d. *per* acre hoeing; usually performed three, and sometimes four times, or until the crop is perfectly clean: the first hoeing is with hoes four inches long, and two and a quarter inches wide. The second hoeing invariably takes place as soon as the first is completed, and is performed with six-inch hoes, by two and a quarter inches wide. By this time the plants are set; the first time of hoeing nothing was cut but the weeds. I endeavour to leave the carrots nine inches apart from each other; sometimes they will be a foot, or even farther asunder.

Hoeing.

"No other expence now attends the crop until the time of taking them up, which is usually about the last week in October, as at that time I generally finish soiling my horses with lucern, and now solely depend upon my carrots, with a proper allowance of hay, as winter food for my horses, until about the first week of June following, when the lucern is again ready for soiling. By reducing this practice to a system, I have been enabled to feed ten cart horses throughout the winter months, for these last six years, without giving them any corn whatever, and have at the same time effected a considerable saving of hay, from what I found necessary to give to the same number of horses, when, according to the usual custom of the country, I fed my horses with corn and hay. I give them to my cart-horses, in the proportion of 70lb. weight of carrots a horse *per* day, upon an average, not allowing them quite so many in the very short days; and something more than that quantity in the spring months, or to the amount of what I withheld in the short winter days. The men who tend the horses, slice some of the carrots in the cut chaff or hay, and barn door refuse; the rest of the carrots they give whole to the horses at night, with a small quantity of hay in their racks: and with this food my horses generally enjoy uninterrupted health. I mention this, as I believe some persons think that carrots *only*, given as food to horses, are injurious to their constitutions; but most of the prejudices of mankind have no better foundation, and are taken up at random, or inherited from their grandfathers.

Time of taking up.

Quantity eaten by Horses.

"So successful have I been with carrots as a winter food for horses, that, with the assistance of lucern for soiling in summer, I have been enabled to prove, by experiments conducted under my own personal inspection, that an able Norfolk team-horse,

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fully worked two journeys a day, winter and summer, may be kept, the entire year round, upon the produce of only one statute acre of land. I have likewise applied carrots with great profit to the feeding of hogs in winter, and by that means have made my straw into a most excellent manure, without the aid of neat cattle; the hogs so fed are sold on Norwich hill to the London dealers, as porkers. The profit of carrots so applied, I shall likewise shew in my subsequent statement; together with an experiment of feeding four Galloway bullocks with carrots, against four others fed in the common way with turnips and hay.

Hogs fed on Carrots; also Cattle.

Mode and Expence of raising the Crops.

"The taking up of the crop is put out to a man who engages women and children to assist him; the work is performed with three-pronged forks; the children cut off the tops, laying them and the roots in separate heaps, ready for the teams to take away. The expence altogether, L. 1, 1s. *per* acre, of not less than seven or eight hundred Winchester bushels. The carting away depends upon the distance of the place where carried to; if not far, the expence will be 15s. to 18s. *per* acre. The value of carrot tops, given to bullocks and sheep in the first winter quarter, more than repays the two last mentioned expences. I take up in autumn a sufficient quantity to have a store to last me out any considerable frost or snow that may happen in the winter months; the rest of the crop I leave in the ground, preferring them fresh out of the earth for both horses and bullocks; for the former, perhaps it would be as well to wash the roots when they are very wet and dirty, though I by no means think washing generally necessary. The carrots keep best in the ground, nor can the severest frosts do them any material injury; the first week in March, it is necessary to have the remaining part of the crop taken up, and the land cleared for barley: the carrots can either be laid in an heap with a small quantity of straw covered over them, or they may be laid into some empty outhouse or barn, in heaps of many hundred bushels, provided they are put together dry. This latter circumstance, it is indispensably necessary to attend to, for, if laid together in large heaps when wet, they will certainly sustain much injury. Such as I want to keep for the use of my horses until the Months of May and June, in drawing over the heaps, (which is necessary to be done the latter end of April, when the carrots begin to sprout at the crown very fast,) I throw aside the healthy and most perfect roots, and have their crowns cut completely off and laid by themselves; by this means, carrots may be kept the month of June out in an high state of perfection." (*Communications to the Board of Agriculture*, Vol. VII. p. 72.)

Keep best in the Ground.

Total Expence *per* Acre.

Mr Burrows next proceeds to state the expence of his crops for four years successively, in which he cultivated forty-nine acres in all; the average of the first three years being L. 10, 13s. 2½d. and the expence of the last year, when he had twenty-five acres, L. 8, 8s. 4d. *per* acre. In these sums, rent, interest of capital, and all other charges are included. He then details at some length the application of the crops, averaging upwards of 800 bushels *per* acre, to the feeding of cart horses, hogs, and cattle—both milk cows and fattening bullocks,—from which there appears to result a clear profit on the first three crops, of no less than L. 27, 18s. 3½d. *per* acre. The fourth crop of twenty-five acres was sold to the tenant who succeeded him in his farm, at twenty guineas *per* acre, the price fixed by neutral men, leaving him a profit of L. 12, 11s. 8d. *per* acre. Mr Burrows was so well convinced of the great advantages of this management, that he began with sixteen acres of carrots on his new farm; and we are told, that the cultivation of this root is becoming more extensive, in consequence of his successful practice.

Average Produce.

Kinds of Crops. Value.

Cultivated in rows.

Carrots, in many instances, are sown by hand, in rows, at narrow intervals for hand-hoeing, the seeds not being easily deposited in a regular manner by the use of the drill-machine. The hand-hoeing is certainly performed more correctly, and with much less labour, when the plants are cultivated in rows.

### 10. *Rape.*

Rape.

Rape is now cultivated to a considerable extent in some districts, not only for the sake of the oil expressed from its seeds, but also for feeding sheep, on land not well adapted to turnips. To the account already given of the culture and uses of this plant in the body of the work, we shall add some remarks by the late Mr Culley of Northumberland, founded on his own excellent practice, in which rape was substituted for fallow on a poor clayey soil.

Time of sowing, &c.

"Rape may be sown from the 24th of May to the 8th of June; but comes to the greatest growth if sown in May. If sown earlier, it is apt to run to seed. From two to three pounds of seed is required *per* acre, sown by a common turnip-seed drill. But as rape-seed is so much larger than turnip-seed, the drill should be wider. When hoed, the rape should be set out at the same distance as turnip plants. The drills should be from 26 to 28 or 30 inches, according to the quantity of dung given. As many ploughings, harrowings, and rollings, &c. should be given, as may be necessary to make that kind of poor soil as fine as possible, and cleared of twitch, &c.: the produce will be from twenty-five to even fifty ton *per* acre, or upwards. But it is not so much the value of the green crop, (although the better the green crop, the better will the wheat be,) as the great certainty of a valuable crop of wheat, that merits attention. The sheep are put on from the beginning to the middle of August; they must have the rape consumed by the middle, or at latest by the end of September, so that the wheat may be got sown, on such poor damp soils, before the autumnal rains take place. The number of sheep must depend upon the goodness or badness of the crop. But as many sheep must be employed as to eat the rape by the middle of September, or end of that month at the latest, for the reasons formerly given. The Burwell red wheat, (so called, from a village in Cambridgeshire,) is always preferred. Poor clays will not allow deep ploughing, consequently, that operation must be governed by the depth of the soil. The land must be made as clean as any naked fallow. There is scarcely an instance known of a crop of wheat sown after rape, and eat off with sheep, being mildewed, and the grain is generally well perfected. Mr Culley has known a crop of wheat after rape, upon a poor moorish thin clay soil, worth much more than the fee simple of the land

Succeeded by Wheat, which is always a good Crop.

Kinds of Crops.

that produced it. He has frequently known land, both after rape and after naked fallow, in the same field: and invariably the rape wheat was better in every respect, than that after naked fallow." (*Husbandry of Scotland*, Vol. II. Appendix, p. 45.)

### 11. *Clovers.*

Clovers.

Clovers enter largely into the succession of crops, on all soils, and in every productive course of management. Before they were introduced into cultivation, when land was exhausted by grain crops, it was necessary to leave it in a state of comparative sterility for several years, before it was either valuable as pasture, or again fit for carrying corn. But at present, clovers are not only indispensable in the cultivation of white and green crops *alternately*, upon very rich soils, but are the foundation of *convertible* husbandry on land that is not so rich as to permit of constant aration, and which therefore requires two or more years pasturage at certain intervals. As the succession of crops forms the subject of the following section, in which we shall have occasion to notice the great value of clover, as a crop in the alternate and convertible systems of husbandry, we shall here consider it without any particular reference to its general utility in that view.

Red clover.

Red clover, or, as it is sometimes called, broad clover, is the kind most generally cultivated on land that carries white and green crops alternately, as it yields the largest produce for one crop of all the other sorts. White and yellow clover are seldom sown with it, unless when several years pasturage is intended. As rye-grass is almost invariably sown with clover, it will be necessary to notice it also in this place.

White and yellow clover.

Rye-grass.

Sown with corn.

Clover and rye-grass are sown *broad-cast*, along with, or upon growing culmiferous corn crops of every kind, and are found to prosper almost equally well with spring sown wheat, barley, and the early varieties of oats. As these seeds are most generally sown in spring, they are usually put in immediately after the land has been pulverized by harrowing in the corn seed, and are themselves covered by one course more of the harrows; or, if the corn is drilled, grass seeds are sown immediately before or after hand hoeing; and the land is then finished by a course of the harrows. A lighter harrow is generally employed in covering grass seeds, than that used for corn. When the land is under an autumn sown crop of wheat or other grain, though the clovers and rye-grass are still sown in spring, the proper period must depend both upon the state of the land, and the progress of the crops; and it may be often advisable to break the crust formed on the surface of tenacious soils, by using the harrow before the clovers are sown, as well as afterwards to cover them. Sometimes the roller only is employed at this time, and there are instances of clover and rye-grass succeeding when sown, without either harrowing or rolling. But it is commonly of advantage to the wheat crop itself, to use the harrows in spring; and the roller alone cannot be depended on, unless the season be very favourable. In some cases grass-seeds are sown by themselves, either in autumn or spring, but rarely on tillage land, the subject of the present chapter.

Kinds of Crops.

Quantity of seed.

The quantity of red clover and rye-grass sown on an acre is exceedingly various; not only according as more or less white or yellow clover is sown along with them, as when pasturage is intended, but, even when they are the only kinds sown, the quantity is varied by the quality of the soils, and the different purposes of hay, soiling, or one year's pasture, to which the crop is to be applied. When pasture is the object, more seed ought to be allowed, than is necessary when the crop is to be cut green for soiling; and for hay, less may suffice than for either of the former. Finely pulverized soils do not require so much seed as clays, on which clover and rye-grass are very frequently sown among autumn or winter sown wheat, when there is more danger of a part of it perishing from being imperfectly covered. In general, eight or ten pounds may be taken as the *minimum* quantity, though there have been instances of good crops from less; and from that to 14 libs or more *per* English statute acre. Rye-grass, commonly at the rate of a bushel *per* acre, but in many cases only half or two thirds of a bushel, is mixed with this weight of clover, and both are sown at the same time. The rye-grass, may be either of the perennial or annual variety, as it is understood that the herbage is to be continued for only one year; and the annual is sometimes sown in preference, as producing a bulkier crop than the perennial.

In the selection of clover and rye-grass seeds, particular attention should be paid to their quality and cleanness; the purple colour of the clover seed denotes that it has been ripe and well saved; and the seeds of weeds may be detected in it by narrow inspection, if there be any; but various noxious weeds are frequently mixed up with the seeds of the rye-grass, which it is difficult either to discover or to separate from them. Between the seeds of the annual and perennial rye-grass, the difference is hardly discernible; and therefore, unless it is of his own growth, the cultivator must depend in a great measure on the character of the person from whom he purchases it. Red clover from Holland or France, has been found to die out in the season immediately after it has been cut or pastured; while the English seed produces plants, which stand over the second, many of them the third year (*General Report of Scotland*, Vol. I. p. 537); thus remaining in the latter case four summers in the ground from the time of sowing.

Annual rye-grass.

Clover and rye-grass, as has been already hinted, are made into hay, cut green for being used in soiling, or depastured. As we shall have occasion to speak again of hay-making, we shall here only notice the principal operations.

Hay.

This sort of herbage ought always to be cut as close to the ground as possible; and the soil, having been previously cleared of any stones that might impede the scythe, and also levelled with a heavy roller, admits of mowing being performed in a very uniform and perfect manner, unless the crop be lodged or broken down by wind. What part of the stems is left by the scythe, is not only lost, but the after growth is neither so vigorous nor so weighty, as when the first cutting is taken as low as possible.

Time of Cutting.

Clover and rye-grass are commonly all mown in June; though in the North, sometimes not till near

Kinds of Crops.

the end of July. The time of mowing must, indeed, be determined by the growth of the plants; but it is a common error to allow them to stand too long. They should in every case be cut down before the seeds are formed, that their juices may be as much as possible retained in the hay. When the stems become hard and sapless, by being allowed to bring their seeds towards maturity, they are of little more value, as provender, than an equal quantity of the finer sort of straw of corn.

Hay-making.

One of the best among the various modes of hay-making, at least for clover and rye-grass, may be described in a few words. As soon as the swath is thoroughly dry above, it is gently turned over (not *tedded* or scattered), without breaking it. Sometimes this is done by the hand, or by a small fork; and some farmers are so anxious to prevent the swath from being broken, that they will not permit the use of the rake-shaft. The grass, when turned over in the morning of a dry day, is put into cocks in the afternoon. The mode of performing this is very simple and expeditious; and none but women, boys, and girls, under the eye of a confidential servant, are usually employed. If the crop is heavy, a row of cocks is placed in the middle ridge of three, and if light, of five ridges. A distinct company of *carriers* and *rakers* is allotted to every such number of ridges; and the separate companies proceed each on its own ground, in the same manner as in reaping grain, which occasions a degree of competition among them for dispatch, clean raking, and neat well-built cocks. The *carriers* gather the hay, and carry it to the ridge where the cock is to be built, by one of the most experienced hands. A *raker* follows the *carrier*, taking up and bringing to the cocks the remains of the swath. There may be in general about five people employed about each row of cocks; a carrier and raker on each side of the ridge on which the cocks are placed, and a person on the ridge, who builds them. But when the crop is not weighty, more rakers are required, as a greater space must be gone over.

As the cocks are thus placed in a line, it is easy to put two or more into one afterwards; and the larger cocks may be speedily drawn together, to be put into tramp-ricks, by means of ropes thrown round their bottoms, and dragged along by a horse. It is impossible to lay down any rules for the management of hay after it is put into cocks; one thing is, however, always attended to, not to shake out, scatter, or expose the hay oftener than is really necessary for its preservation. Sometimes the cocks have been put up so large, that they never required to go to a tramp-rick, but were carted to the stack-yard, without ever being broken, and put up in alternate layers with old hay. But where this is attempted, there must not be much clover. The practice of mixing the new with the old hay, is, however, a good one, and saves a great deal of time and labour, at the same time that the old hay is much improved by the mixture.

The best managers disapprove of spreading out the swaths of clover and rye-grass, though this is often necessary with natural grasses, which are cut and harvested later in the season. The more the swath is kept unbroken, the hay is the greener, and the more fragrant.

Another mode of hay-making, said to have been originally practised in Lancashire, has been found to answer well in the moist atmosphere of the west of Scotland. This is called *tippling* or *rippling;* and if the grass be dry, the operation begins as soon as it is mown. "In making a tipple, a person, with his right hand, rolls the swath inwards, until he has a little bundle; then the same is done by the left, until both meet, and form eight to twelve pounds, or nearly so. This bundle is then set up against the legs, or between the feet; a rope is twisted off the grass, while the bundle is supported in this manner, and tied round it, near its top; and from the top are drawn up a few straggling stems which are twisted, to make the tipple taper to a point, and give it as much a conical shape as possible. If the crop is strong, there is a row of tipples placed on each swath; if light, two of these are put into one row. After standing a few hours, they become so smooth on the outside, that the heaviest rains seldom wet them through; and when wet, they are soon dried again in good weather. As soon as ready, they are put into the summer-rick, or, if very dry, even the winter-stack, but are never opened out, or *tedded*, to make them dry, as they never require it. By this method not a blade is lost, and the hay is nearly as green as a leaf dried in a book. In a moderate crop, one woman will tipple to one mower, and a woman will rake to two tipplers, or two swathers. But where the crop is strong, it may require three women to keep pace with two mowers. After the hay is put up in this manner, the crop may be considered as secure, though it may continue wet weather for a considerable length of time." (*General Report of Scotland*, Vol. II. p. 11.)

Stacking.

Hay is commonly carried to the stack-yard, and built either in circular or oblong stacks, the latter form being most generally approved of, and carefully thatched, as has been already observed in regard to corn. It is never advisable to allow this kind of hay to become heated, in any considerable degree, in the stack, though a slight exudation, with a very gentle warmth, is usually perceptible, both in the field ricks and in the stacks, for a few days after they are built. but this is a quite different thing from that intentional heating, carried so far, in many instances, as to terminate in conflagration.

Produce per Acre.

The weight of hay from clover and rye-grass varies, according to the soil and the season, from one to three tons per English acre, as it is taken from the tramp-ricks; but after being stacked, and kept till spring, the weight is found to be diminished 25 or 30 *per cent.* Its price per ton depends entirely on situation; at a distance from towns or large villages, in ordinary seasons, the price is usually very low, and the whole of it is generally consumed on the farm that produced it. Its intrinsic value as fodder, in comparison with the straw of beans or peas, may be in the proportion of three to two; and with the finest straw of corn crops, in the proportion of two to one.

Objections to Rye grass.

Many intelligent cultivators consider rye-grass as

Kinds of Crops.

a very severe crop for the soil; and it is alleged, that wheat does not succeed well after the herbage with which it is intermixed in any considerable quantity. Other plants have accordingly been recommended as a substitute for rye-grass, and cocksfoot (*Dactylis glomerata*), has been tried, apparently with great success, by Mr Coke, of Holkham in Norfolk, and others. But this is a very coarse grass when allowed to rise to any height, and the use of it for hay has not yet been ascertained.

Cocksfoot recommended in its stead.

After-growth.

When the hay crop is cut and removed, there is commonly a vigorous aftergrowth, which may be either cut or pastured. As this consists almost exclusively of red clover, and is extremely succulent, it is seldom made into hay, owing to the difficulty of getting it thoroughly dried at a late period of summer, when other more urgent operations usually employ all the labourers of a farm. If it be cut for this purpose, the best method of saving it is, to mix it up with straw, which will absorb a part of its juices. It is often cut green, as a part of the soiling system; or, where a sheep stock is kept, pastured by the old ewes, or other sorts, that are to be fattened the ensuing winter on turnips.

Soiling.

On all farms, under correct management, a part of this crop is cut green, for the working horses, often for milk cows, and, in some instances, both for growing and fattening cattle. This mode of consuming it is known by the name of *soiling*. There can be no doubt of the advantages of this practice, in regard to horses and cows; but for young, and for fattening beasts, a sufficient number of experiments are not known to have been yet made with any great degree of accuracy. Young animals require exercise in the open air, and, probably, will not be found to thrive so well in houses or fold-yards, during summer, as on pastures; and though in every case there is a great saving of food, the long, woody, and comparatively naked stems of the plants, with leaves always more or less withered, are perhaps not so valuable in the production of beef on fattening stock, as a much smaller weight of herbage taken in by pasturage. Milk-cows, however, are so impatient of heat and insects, that this way of feeding them, at least for a part of the day, in warm weather, ought to be more generally adopted; and the convenience of having working horses always at hand, besides that they fill their stomachs speedily, is of not less importance than economy. *

In feeding cattle with green clover, attention must be paid to prevent swelling, or *hoving*, which is very apt to take place when they are first put on this food, especially if it be wet with rain or dew; and cattle are exposed to this danger, whether they are sent to depasture the clover, or have it cut and brought home to them; though, if the plants be somewhat luxuriant, the danger is greater in the former case. After being accustomed to this rich food for a few days, during which it should be given rather sparingly, the danger is much diminished; but it is never safe to allow milk-cows, in particular, to eat large quantities of wet clover.

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Saving of Seed.

We have hitherto spoken of red clover and rye-grass, as cultivated for the sake of the stems and leaves, and shall now add a few words about the management required when the object is to save their seeds. Rye-grass seed is gathered in almost every part of Britain, but clover seed can seldom be saved in any profitable quantity in the northern parts. In Scotland, red clover is never cultivated for seed.

Rye-grass Seed.

The common practice in regard to rye-grass is, to let the mixed crop of that and clover stand till the seeds of the former have attained a considerable degree of ripeness, when it is cut down and made into hay in the usual manner; and the seeds of the rye-grass are separated by the use of the flail, commonly before the hay is put into the field-ricks. Sometimes, when but a small quantity is wanted, the hay is merely shaken well upon a cloth, when it is building in the stack-yard; or afterwards, in the stable-loft, before it is put into the horses' racks. But in all of these methods, in order to obtain good seed, the clover must remain uncut beyond the proper season; and it is thus materially injured in quality, while the value of the rye-grass seed, in such a crop, is merely a secondary consideration.

When seed is the principal object of the culture of rye-grass, it ought not to be mixed with clover at all, though it may be sown along with any of the kinds of corn already mentioned, and it is treated the year after in every respect as a crop of corn; bound up in sheaves, built in stacks, thrashed with the flail, and dressed by the winnowing machine, in the same manner.

The difficulty of distinguishing between the annual and perennial varieties of rye-grass has led to the practice, in some places, of cutting or pasturing the first year's crop, and taking a crop for seed in the second year. If the growth of the rye-grass plants be close and vigorous the second year, there is reason to be satisfied that the seed is of the perennial variety; and though red clover has been sown with the rye-grass, a great part of it disappears by that time, and forms but a small portion of the second year's cutting.

Clover Seed.

The seed of red clover is saved with more labour and difficulty. As the plant does not perfect its seed early in summer, it is necessary to take off the first growth, either by feeding or cutting. In the first case, it is eaten till about the end of May, frequently by ewes and lambs; and this is understood to be an advantageous practice, because the land is less exhausted, and the green food is of great value for stock in the spring months. It is not uncommon, however, to cut the first growth for a hay crop, and this should be done earlier than usual.

The growth thus reserved for seed must be suffered to remain till the husks become perfectly brown, when it is cut and harvested in the usual manner, leaving it on the field till it is very dry and crisp,

* See *Communications to the Board of Agriculture*, Vol. VII. Brown's *Treatise on Rural Affairs*, Vol. II. *General Report of Scotland*, Vol. II. and III.

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that the seeds may become more fully hardened; it may then be laid up dry, to be thrashed out at the farmer's convenience.

Much labour and expence are necessary in separating the seed from the capsule, or seed-coat, especially when it is effected by thrashing, which seldom costs less than from five to six or seven shillings per bushel. By the use of mills the work may be done much cheaper.

The produce in seed may generally be from three to four or five bushels per acre, when perfectly clean, weighing from two to three hundredweight. But there is great uncertainty in the produce of clover seed, from the lateness of the season at which it becomes ripe; and the fertility of the soil is considerably impaired by such a crop. Yet the high value of the seed is a great inducement to the saving of it, in favourable situations. (Dickson's *Practical Agriculture*, Vol. II. p. 863.)

Seeds for Pasture.

When it is intended to retain the land in pasture for several years, the quantity of red clover is diminished, and several kinds of more permanent herbage are added, the most common of which are, white and yellow clover, and ribwort. No general rule can be laid down as to the proper quantity of each of these kinds; in some cases red and white clover are sown in equal proportions, and in others the latter is made greatly to predominate. The yellow clover and ribwort are not often sown at the rate of more than two or three pounds per acre. It is scarcely necessary to add, that, in this case, the rye-grass should always be of the perennial sort.

When permanent pasture is the object, a still greater variety of seeds has been recommended. But as cultivators are by no means agreed on this point, and as the different kinds and proportions, which are thought best adapted to different soils, have none of them the sanction of extensive experience, we shall refer the reader to the third volume of *Communications to the Board of Agriculture*, which is wholly occupied with essays on the best means of breaking up old grass-lands, and restoring them after a few years to permanent pasture.

## Sect. VII. Succession of Crops.

Succession of Crops.

There is no branch of husbandry that requires more judgment, nor any on which the profits of the farmer more depend, than the order in which the several crops cultivated are made to succeed one another. This is a point which has been discussed at some length in the principal article (See Index, *Rotation*); and the most material change that has taken place since is, a more general observance of the rule, that culmiferous crops, ripening their seeds, should not be repeated, without the intervention of pulse, roots, herbage, or fallow. This rule is recognized in the practice and writings of all judicious cultivators, more generally, perhaps, than any other in the whole compass of the art of agriculture.

First General Rule.

With regard to the particular plants that enter into the course of cropping, these, it is evident, must be such as are suited to the soil and climate, though they will be somewhat varied by local circumstances; such as the proximity of towns and villages, where there is a greater demand for turnips, potatoes, hay, &c. than in thinly peopled districts. In general, beans, and clover with rye-grass, are interposed between corn crops on clayey soils, and turnips, potatoes, and clover and rye-grass, on dry loams and sands, or what are technically known by the name of turnip soils. A variety of other plants, such as peas, tares, cabbages, and carrots, occupy a part, though commonly but a small part, of that division of a farm which is allotted to green crops. This order of succession is called the system of *alternate husbandry*; and on rich soils, or such as have access to abundance of putrescent manure, it is certainly the most productive of all others, both in food for man and for the inferior animals. One half of a farm is, in this course, always under some of the different species of *Cereal gramina*, and the other half under pulse, roots, cultivated herbage, or plain fallow.

Alternate System.

But the greater part of the arable land of Britain cannot be maintained in a fertile state under this management; and sandy soils, even though highly manured, soon become too incohesive under a course of constant tillage. It therefore becomes necessary to leave that division, or *break*, that carries cultivated herbage, to be pastured for two years or more, according to the degree of its consistency and fertility; and all the fields of a farm are treated thus in their turn, if they require it. This is called the system of *convertible husbandry;* a regular change being constantly going on from aration to pasturage, and *vice versa*.

Convertible System.

Another rule with regard to the succession of crops, is not to repeat the same kind of crop at too short intervals. Whatever may be the cause,—whether it is to be sought for in the nature of the soil, or of the plants themselves, experience clearly proves the advantages of introducing a diversity of species into every course of cropping. When land is pastured several years before it is brought again under the plough, there may be less need for adhering steadily to this rule; but the degeneracy of wheat and other corn crops, recurring upon the same land every second year for a long period, has been very generally acknowledged. It is the same with what are called green crops; beans and peas, potatoes, turnips, and in an especial manner, red clover, become all of them much less productive, and much more liable to disease, when they come into the course, upon the same land, every second, third, or fourth year. But what the interval ought to be has not yet been determined, and probably cannot (from the great number of years that experiments must be continued to give any certain result) be determined, until the component parts of soils, and particularly the sort of vegetable nourishment which each species of plants extracts from the soil, have been more fully investigated.

Second General Rule.

A change of the *variety*, as well as of the *species*, and even of the plants of the same variety, is found to be attended with advantage; and in the latter case, or a change of seed, the species and variety being the same, the practice is almost universal. It is well known, that, of two parcels of wheat, for instance, as much alike in quality as possible, the one, which had grown on a soil differing much from that on which it is to be sown, will yield a better produce than the other that grew in the same, or a similar

Third General Rule.

Manures. soil and climate. The farmers of Scotland, accordingly, find that wheat from the south, even though it be not, as it usually is, better than their own, is a very advantageous change; and oats and other grain, brought from a clayey to a sandy soil, other things being equal, are more productive than such as grew on the sandy soil.

## Sect. VIII. Manures.

Manures. Manures having been treated of under two different divisions of the principal article, we shall now very briefly notice the several substances most extensively employed; pointing out any change that may have occurred in their management and application; and conclude with merely mentioning the various articles of this kind that are to be procured only in small quantities, or in particular situations, and which are therefore used on a very limited scale.

### 1. *Farm-yard Dung.*

Farm-yard Dung. This manure, composed chiefly of the straw of grain, and the excrementitious substances of live stock, is the principal, and, in most instances, the only fertilizer of the soil to which farmers have access. Its use is so universal and so well known, that a very few observations will suffice.

Quantity made from a given weight of straw. As straw is the basis of this compost, every judicious farmer takes care to have his crops cut as low as possible, as it is evident to every one that a few inches of straw towards the root-end adds much to the weight of the crop. From every ton of dry straw, about three tons of farm yard dung may be obtained, if the after-management be properly conducted; and, as the weight of straw per acre runs from 1 ton to 1½, about 4 tons of dung, on an average of the different crops, may be produced from the straw of every acre under corn. (*Husbandry of Scotland*, Vol. II.)

The straw is served out to cattle and horses in the houses and fold-yards, either as provender or litter, commonly for both purposes; and turnips in winter, and green clover in summer, on which food the animals pass a great deal of urine, afford the means of converting the straw into a richer manure than if it were eaten alone.

Management. All the dung from the houses, as they are cleaned out, ought to be regularly spread over the yards, in which young cattle are left loose, where litter is usually allowed in great abundance; or over the dunghill itself, if there be one at hand. This renders the quality of the whole mass more uniform; and the horse-dung, which is of a hot nature, promotes the decomposition of the woody fibres of the straw.

At a convenient season, usually during the frosts of winter, this mass of materials is carted out to the field in which it is to be employed, and neatly built in dunghills of a square form, three or four feet high, and of such a length and breadth as circumstances may require. What is laid up in this manner early in winter, is commonly sufficiently prepared for turnips in June; but if it be not carried from the straw-yards till spring, it is necessary to turn it once or oftener, for the purpose of accelerating the decomposition of the strawey part of the mass. When dung is applied to fallows in July or August, preparatory to autumn sown wheat, a much less degree of putrefaction will suffice than for turnips—a clay soil, on which alone fallows should ever be resorted to, not requiring dung so much rotted as a finely pulverized turnip soil; and besides, as the wheat does not need all the benefit of the dung for some time, the woody fibre is *gradually* broken down in the course of the winter, and the nourishment of the plants continued till spring, or later, when its effects are most beneficial.

Application. In the application of dung to land under tillage, particular attention should be paid to the cleanness of the soil; and to use it at the time when, from the pulverization of the ground, it may be most intimately mixed with it. The most common time of manuring with farm-yard dung is, therefore, either towards the conclusion of the fallowing operations, or immediately before the sowing of fallow crops. If no dung can be procured but what is made from the produce of the farm, it will seldom be possible to allow more than ten or twelve tons to every acre, when the land is managed under a regular course of white and green crops; and it is thought more advantageous to repeat this dose at short intervals, than to give a larger quantity at once, and at a more distant period in proportion. (*General Report of Scotland*, Vol. II. p. 517.)

Farm-yard dung, it is well known, is greatly reduced in value by being exposed to the atmosphere in small heaps, previous to being spread, and still more after being spread. Its rich juices are exhaled by the sun, or washed away by the rains, and the residuum is comparatively worthless. This is in an especial manner the case with long fresh dung, the far greater part of which consists of wet straw in an entire state. All careful farmers, accordingly, spread, and cover in their dung with the plough, as soon as possible after it is brought on the land.

Fresh dung. It has been urged by a celebrated chemist, that farm-yard dung ought not to be allowed to ferment in any considerable degree, as during a violent fermentation, a large quantity not only of fluid, but likewise of gaseous matter is lost, which, if retained by the moisture in the soil, would be capable of becoming an useful nourishment to plants. He therefore recommends that it should be applied after a slight incipient fermentation, which he admits to be useful in bringing on a disposition in the woody fibre to decay and dissolve; and this is always, he adds, in great excess in the refuse of a farm. (Davy's *Agricultural Chemistry*, p. 302. 8vo.)

Objections to its use on turnip soils. From a recent publication (*Husbandry of Scotland*, Vol. I. p. 174.), the practice of the best farmers of turnip soils in Scotland appears to be decidedly adverse to the use of fresh dung; and its inutility, or rather injurious effects, from its opening the soil too much, is a matter of experience with every one who cultivates drilled turnips on a large scale. As the whole farm-yard dung, on such land, is applied to the turnip crop, it must necessarily happen that it should be laid on in different stages of putrefaction; and what is made very late in spring,

Manures. often after a very slight fermentation, or none at all. The experience of the effects of recent dung is accordingly very general, and the result, in almost every case is, that the growth of the young plants is slow,—that they remain long in a feeble and doubtful state,—and that they seldom, in ordinary seasons, become a full crop, even though twice the quantity that is given of short *muck* has been allowed.

On the other hand, when the manure is considerably decomposed, the effects are immediate, the plants rise vigorously, and soon put forth their *rough* leaf, after which, the beetle or fly does not seize on them; and, in a few weeks, the leaves become so large, that the plants probably draw the greatest part of their nourishment from the atmosphere.

Though it were true, therefore, that more nutritive matter were given out by a certain quantity of dung, applied in a recent state, and allowed to decompose gradually in the soil, than if applied after undergoing fermentation and putrefaction, the objection, arising from the slowness of its operation, would, in many instances, be an insuperable one with farmers.

But there seems reason to doubt whether fresh strawy manure would ferment much in the soil, after being spread out in so small a quantity as has been already mentioned; and also, whether, in the warm dry weather of summer, the shallow covering of earth given by the plough, would not permit the gaseous matters to escape, to a much greater amount than if fermentation had been completed in a well built covered dunghill.

Another great objection to the use of fresh farm yard dung is, that the seeds and roots of those plants with which it commonly abounds, spring up luxuriantly on the land; and this evil, nothing but a considerable degree of fermentation can obviate. The mass of materials consists of the straw of various crops, some of the grains of which, after all the care that can be taken, will adhere to the straw,—of the dung of different animals voided, as is often the case with horses fed on oats, with the grain in an entire state,—and of the roots, stems and seeds of the weeds that had grown among the straw, clover and hay, and such as had been brought to the houses and fold-yards with the turnips and other roots given to live stock.

No rule of universal application can be laid down on this subject; the degree of decomposition to which farm-yard dung should arrive, before it can be deemed a profitable manure, must depend on the texture of the soil, the nature of the plants, and the time of its application. In general, clayey soils, more tenacious of moisture, and more benefited by being rendered incohesive and porous, may receive manure less decomposed than well pulverized turnip soils require. Some plants, too, seem to thrive better with fresh dung than others,—potatoes in particular; but all the small-seeded plants, such as turnips, clover, carrots, &c. which are extremely tender in the early stage of their growth, require to be pushed forward into luxuriant vegetation with the least possible delay, by means of short dung. The season when manure is applied, is also a material circumstance. In spring and summer, whether it be used for corn or green corps, the object is to produce an immediate effect, and it should therefore be more completely decomposed than may be necessary, when it is laid on in autumn for a crop whose condition will be almost stationary for several months.

### 2. *Lime.*

Lime. Next to farm-yard dung, lime is in most general use as a manure, though it is one of a quite different character; and when judiciously applied, and the land laid to pasture, or cultivated for white and green crops alternately, with an adequate allowance of putrescent manure, its effects are much more lasting, and, in many instances, still more beneficial than those of farm-yard dung. Fossil manures " must produce their effect, either by becoming a constituent part of the plant, or by acting upon its more essential food, so as to render it more fitted for the purposes of vegetable life." (*Davy's Agricultural Chemistry*, p. 314.) It is, perhaps, in the former of these ways, that wheat and some other plants are brought to perfection after lime has been applied, upon land that would not bring them to maturity by the most liberal use of dung alone.

" The most common form in which lime is found on the surface of the earth, is in a state of combination with carbonic acid or fixed air. If a piece of limestone or chalk be thrown into a fluid acid, there will be an effervescence. This is owing to the escape of the carbonic acid gas. The lime becomes dissolved in the liquor. When limestone is strongly heated, the carbonic acid gas is expelled, and then nothing remains but the pure alkaline earth; in this case, there is a loss of weight, and if the fire has been very high, it approaches to one-half the weight of the stone, but, in common cases, limestones, if well dried before burning, do not lose much more than from 35 to 40 *per cent*., or from seven to eight parts out of twenty. When burned lime becomes mild, it regains its power of effervescing, and is the same chemical substance as chalk or limestone. Loss of weight by burning.

" When newly burnt lime is exposed to air, it soon falls into powder; in this case it is called slacked lime, and the same effect is immediately produced by throwing water upon it, when it heats violently, and the water disappears. Slacked lime is merely a combination of lime with about one-third of its weight of water, that is, 55 parts of lime absorb 17 parts of water. Slacked Lime.

" When lime, whether freshly burned or slacked, is mixed with any moist fibrous vegetable matter, there is a strong action between the lime and the vegetable matter, and they form a kind of compost together, of which a part is usually soluble in water. By this kind of operation, lime renders matter which was before comparatively inert nutritive; and as charcoal and oxygen abound in all vegetable matters, it becomes at the same time converted into carbonate of lime. Operation of Lime.

" Mild lime, powdered limestone, marls, or chalks, have no action of this kind upon vegetable matter; by their action they prevent the too rapid decomposition of substances already dissolved, but they have no tendency to form soluble matters.

" It is obvious, from these circumstances, that the

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operation of quicklime, and marl or chalk, depends upon principles altogether different. Quicklime, in being applied to land, tends to bring any hard vegetable matter that it contains, into a state of more rapid decomposition and solution, so as to render it a proper food for plants. Chalk and marl, or carbonate of lime, will only improve the texture of the soil, or its relation to absorption; it acts merely as one of its earthy ingredients. Quicklime, when it becomes mild, operates in the same manner as chalk; but, in the act of becoming mild, it prepares soluble out of insoluble matter.

" The solution of the question, whether quicklime ought to be applied to a soil, depends upon the quantity of inert vegetable matters that it contains. The solution of the question, whether marl, mild lime, or powdered limestone, ought to be applied, depends upon the quantity of calcareous matter already in the soil. All soils are improved by mild lime, and ultimately by quicklime, which do not effervesce with acids, and sands more than clays." (Davy's *Agricultural Chemistry*, p. 315, et seq.)

From the mode in which lime operates, it necessarily follows that quicklime should not be applied to lands that contain much soluble matter, nor be mixed up in composts with animal manures.

Magnesian Limestone.

" It had been long known to farmers in the neighbourhood of Doncaster, that lime made from a certain limestone, applied to the land, often injured the crops considerably. Mr Tennant, in making a series of experiments upon this peculiar calcareous substance, found that it contained magnesia; and on mixing some calcined magnesia with soil, in which he sowed different seeds, he found that they either died or vegetated in a very imperfect manner, and the plants were never healthy. And with great justice and ingenuity, he referred the bad effects of the peculiar limestone to the magnesian earth it contains." (Id. p. 322.) Yet it is advantageously employed in small quantities, seldom more than 25 or 30 bushels to the acre. A simple test of magnesia in the limestone, is the circumstance of its effervescing little when plunged into an acid, and its rendering diluted nitric acid or aquafortis milky. Stones of this kind are usually coloured brown or pale yellow, and are found in several counties of England, and in many parts of Ireland, particularly near Belfast.

Quantity applied to different soils.

With regard to the quantity of lime that ought to be applied to different soils, it is much to be regretted that Sir Humphry Davy has not thought proper to enter fully into the subject. Clays, it is well known, require a larger quantity than sands or dry loams. It has been applied, accordingly, in almost every quantity from 100 to 500 bushels or upwards, per acre. About 160 bushels are generally considered a full dressing for lighter soils, and 80 or 100 bushels more for heavy cohesive soils.

General Rules.

In the application of lime to arable land, there are some general rules commonly attended to by diligent farmers, which we shall give nearly in the words of a recent publication.

1. As the effects of lime greatly depend on its intimate admixture with the surface soil, it is essential to have it in a powdery state at the time it is applied.

2. Lime having a tendency to sink in the soil, it should be ploughed in with a shallow furrow.

3. Lime may either be applied to grass land, or to land in preparation for green crops or summer fallow, with almost equal advantage; but, in general, the latter mode of application is to be preferred.

4. Lime ought not to be applied a second time to moorish soils, unless mixed up as a compost, after which the land should be immediately laid down to grass.

5. Upon fresh land, the effect of lime is much superior to that of dung. The ground, likewise, more especially where it is of a strong nature, is more easily wrought; in some instances, it is said, " the saving of labour would be sufficient to induce a farmer to lime his land, were no greater benefit derived from the application than the opportunity thereby gained of working it in a more perfect manner. (*General Report of Scotland*, Vol. II. p. 536.)

Effects of Lime in improving Hilly land laid down to pasture.

In improving hilly land, with a view to pasture, a much smaller quantity of lime has been found to produce permanent and highly beneficial effects, when kept as much as possible near the surface, by being merely harrowed in with the seeds, after a fallow or green crop, instead of being buried by the plough. As this is a matter of much importance to farmers of such land, especially when lime must be brought from a great distance, as was the case in the instance to which we are about to allude, the successful practice of one of the most eminent farmers in Britain cannot be too generally known.

" A few years after 1754," says Mr Dawson, " having a considerable extent of outfield land in fallow, which I wished to lime previous to its being laid down to pasture, and finding that I could not obtain a sufficient quantity of lime for the whole in proper time, I was induced, from observing the effects of fine loam upon the surface of similar soil, even when covered with bent, to try a small quantity of lime on the surface of this fallow, instead of a larger quantity ploughed down in the usual manner. Accordingly, in the autumn, about twenty acres of it were well harrowed, and then about fifty-six Winchester bushels only, of unslacked lime, were, after being slacked, carefully spread upon each English acre, and immediately well harrowed in. As many pieces of the lime, which had not been fully slacked at first, were gradually reduced to powder by the dews and moisture of the earth,—to mix these with the soil, the land was again well harrowed in three or four day thereafter. This land was sown in the spring with oats, with white and red clover and rye-grass seeds, and well harrowed, without being ploughed again. The crop of oats was good; the plants of grass sufficiently numerous and healthy; and they formed a very fine pasture, which continued good until ploughed some years after, for corn.

" About twelve years afterwards, I took a lease of the hilly farm of Grubbet; many parts of which, though of an earthy mould tolerably deep, were too steep and elevated to be kept in tillage. As these lands had been much exhausted by cropping, and were

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full of couch-grass, to destroy that, and procure a cover of fine grass, I fallowed them, and laid on the same quantity of lime per acre,—then harrowed, and sowed oats and grass-seeds in the spring; exactly as in the last mentioned experiment. The oats were a full crop, and the plants of grass abundant. Several of these fields have been now above thirty years in pasture, and are still producing white-clover and other fine grasses; no bent or fog has yet appeared upon them. It deserves particular notice, that more than *treble* the quantity of lime was laid upon fields adjoining, of a similar soil, but which being fitter for occasional tillage, upon them the lime was ploughed in. These fields were also sown with oats and grass-seeds. The latter throve well, and gave a fine pasture the first year; but afterwards the bent spread so fast, that, in three years, there was more of it than of the finer grasses."

The conclusions which Mr Dawson draws from his extensive practice in the use of lime and dung, deserve the attention of all cultivators of similar land.

Conclusions as to the effects of lime and dung.

"1. That animal dung dropt upon coarse, benty pastures, produces little or no improvement upon them; and that, even when sheep or cattle are confined to a small space, as in the case of folding, their dung ceases to produce any beneficial effect, after a few years, whether the land is continued in pasture, or brought under the plough.

"2. That even when land of this description is well fallowed and dunged, but not limed, though the dung augments the produce of the subsequent crop of grain, and of grass also for two or three years, that thereafter its effects are no longer discernible either upon the one or the other.

"3. That when this land is limed, if the lime is kept upon the surface of the soil, or well mixed with it, and then laid down to pasture, the finer grasses continue in possession of the soil, even in elevated and exposed situations, for a great many years, to the exclusion of bent and fog. In the case of Grubbet-hills, it was observed, that more than thirty years have now elapsed. Besides this, the dung of the animals pastured upon such land adds every year to the luxuriance, and improves the quality of the pasture; and augments the productive powers of the soil when afterwards ploughed for grain; thus producing, upon a benty outfield soil, effects similar to what are experienced when rich infield lands have been long in pasture, and which are thereby more and more enriched.

"4. That when a large quantity of lime is laid on such land, and ploughed down deep, the same effects will not be produced, whether in respect to the permanent fineness of the pasture, its gradual amelioration by the dung of the animals depastured on it, or its fertility when afterwards in tillage. On the contrary, unless the surface is fully mixed with lime, the coarse grasses will in a few years regain possession of the soil, and the dung thereafter deposited by cattle will not enrich the land for subsequent tillage.

"*Lastly*, It also appears from what has been stated, that the four-shift husbandry is only proper for very rich land, or in situations where there is a full command of dung: That by far the greatest part of the land of this country, requires to be continued in grass two, three, four, or more years, according to its natural poverty: That the objection made to this, viz. that the coarse grasses in a few years usurp possession of the soil, must be owing to the surface soil not being sufficiently mixed with lime, the lime having been covered too deep by the plough." (*Farmer's Magazine*, Vol. XIII. p. 69.)

Quantity of calcareous matter in different Limestones.

Limestones differ much in purity, or in the quantity of calcareous matter which they contain. According to Mr Headrick (*Farmer's Magazine*, Vol. V. p. 451.), it is usually from 60 to 85 per cent.; but he afterwards analyzed some limestones from the county of Fife, which contained $99\frac{1}{2}$ per cent. of carbonate of lime, the residuum being fine clay. Farmers generally estimate the purity of limestones, by the quantity of slacked lime produced from a given quantity of burnt limestone, or shells as it is usually called, the pulverized lime of the best shells being three times the measure of the shells. But it is easy to ascertain the quantity of calcareous matter in the stone itself, by the use of muriatic acid; that stone being the best which leaves the least sediment, the lime itself dissolving in the acid.

### 3. *Marls.*

Kinds.

Marl, which was more extensively employed as a manure in former times than it has been of late, since the properties of lime have been better understood, is usually divided into *stone*, *clay*, and *shell* marl, of which the last is the most valuable. All marls contain a portion of calcareous matter, and their operation is not materially different from that of mild lime, as has been formerly noticed; but the greater quantity required, owing to the smaller proportion of calcareous matter which they contain, confines the use of them to a few miles around the places where they are found. The effects of marl are slower than those of quicklime, but, from the earthy substances combined with the calcareous matter, and the larger quantity usually applied, the staple of the soil is deepened, and the benefit is considered more durable.

### 4. *Sea-Weed.*

Sea-Weed.

This is an excellent manure though not lasting in its effects, suited to all soils and crops, with the exception perhaps of clovers of the first year's growth. It should be applied fresh as it is gathered, if the land be ready to receive it, otherwise it may be mixed up with fresh dung, or used as a top-dressing to grass lands.

### 5. *Bones and Horns.*

Bones.

Bones are a source of manure too little attended to in most places, though their value is well ascertained by a pretty extensive experience of their effects in several districts. The following particulars were transmitted from Yorkshire, in answer to some queries proposed by the writer of this article.

"1. It is thought that all the bones of every animal are *not* equally valuable; but all the bones of an animal suitable for manure are equally good; and are much better when fresh.

"2. The bones which are best filled with oil and marrow are certainly the best manure; and the

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parts generally used for buttons and knife-hafts are the thigh and shank-bones.

"3. The *powdered* bones are dearer, and generally used for hot-beds in gardens, being too expensive for the field, and not so durable a manure as *bruised* bones, though for a short time more productive.

"4. A dry, light or gentle soil, is best adapted for the use of bone manure, as it is supposed that, in land which retains wet, the nutritive part of the bone washes to the surface of it, and does not incorporate sufficiently with the soil.

How applied.

"5. The autumn is the most proper time for the use of this manure, which should then be laid on fallows for a turnip crop. The powder only should be used on a green crop, as the bruised bones would interrupt the progress of the scythe.

"6. The effects produced on different crops are generally good on such soil as named in No. 4.

"7. Bruised bones are better when mixed with ashes or any other manure, as the juice of the bones is then more equally spread over the field.

"8. Bone manure ought to be ploughed into the land in tillage. On grass, the powder should be sown in by the hand.

"9. This manure is used on land before described, to the extent of several thousand acres, in the *higher* parts of Nottinghamshire, and the *wolds* (or high land) in Lincolnshire, and the East and West Riding of Yorkshire.

"10. The primary object of keeping a bone-mill is the bruising of bones, which pays better than selecting and selling such as are suitable for buttons, &c.

Mill for bruising Bones.

"11. In an agricultural district, where the generality of the land is of the nature before mentioned as best suited for bone manure, a mill for the purpose of bruising bones would certainly indemnify the proprietors. The cost of a mill is from L. 100 to L. 200. As to the number of miles the manure may be carried, the proprietors of the mill will be best able to judge of that." See Plate VIII.

Horns.

Horn, says Sir H. Davy, is a still more powerful manure than bone, as it contains a larger quantity of decomposable animal matter. The shavings or turnings of bone, though they cannot be procured in great abundance, are much esteemed as a manure, and have been long known to the farmers in the west of Scotland, who sometimes bring them from Ireland. They are sown by the hand as a top-dressing for wheat and other crops.

### 6. *Burnt Clay.*

Burnt Clay,

This is a mode of preparation which has been recently introduced into the west of Scotland from Ireland, by Mr Craig at Cally, in the Stewartry of Kirkcudbright. It has been tried with great success; and if it should succeed generally, it will form a new æra in the practice of agriculture, and contribute essentially, to the general improvement of the country. The want of manure has been always felt as a great obstruction to the cultivation of waste lands, and it has been thought that the limited quantity to be had is more profitably applied to the land at present under tillage than to new land. But if burnt clay, or *tilly* subsoil, have the effect of producing full crops of turnips, from the consumption of which enriching ma-

or *tilly* subsoil.



nures may be always procured, there are few situations in which an almost unlimited supply of it may not be got, at a very small expence. We cannot do better than give the substance of Mr Craig's letter to Mr Boyd of Merton-Hall, in the contiguous county of Wigton, on this highly interesting subject. It is dated 28th January 1815.

Manures.

"Being perfectly convinced, both from ocular demonstration, and personal experience, of the infinite utility of clay ashes, as a manure for every kind of crop, as well as a top-dressing for grass lands, I am extremely anxious that the use of them should become universal. I shall, therefore, have much pleasure in communicating to you every information on the subject, and I have now sat down to accomplish that object, as far as lies in my power.

Practised in Ireland;

"Having had occasion, for some years past, to go repeatedly to Ireland, on the business of Mr Murray's estate there, I was struck with the mode adopted, in some parts of that country, of burning clay, and making use of the ashes, in preference to lime, of which there is such abundance. The method also adopted of causing the clay, just as it is dug out of the ground, without the assistance of any combustible, except merely to set it on fire, and without preparation of any sort, to burn of itself, arrested my attention; and having witnessed the crops of wheat and corn of every description, as well as flax and potatoes, luxuriant almost beyond credibility, produced from stiff clay soils, without the aid of any other manure than ashes so obtained, I determined to make the experiment at home. On my return, I accordingly commenced operations, and have practised the burning of subsoil for three years with the greatest success. I felt considerable difficulty at first for want of clay; but I hit upon a vein or bed of tenacious subsoil, partly *till*, and partly clay, which answers the purpose quite well, though I do not apprehend it is so good as clay. The ashes I have hitherto applied solely to the production of turnips; but within the last ten days, I have laid nearly five hundred cart-loads on grass lands as a top-dressing. My turnip crops from ashes have exceeded any thing of the kind in this neighbourhood. I was twice in London in the course of last summer and harvest, and in my way to and from town, I saw no turnips equal to my crop, though I passed through Berwickshire and Northumberland.

and of late in Scotland.

Ashes used for Turnips; and as a Top-Dressing to Grass Lands.

"Last season, by way of experiment, I manured part of my turnip field with the best stable dung, which was ploughed in the same day it was led out of the yard; the remainder with ashes. The seed, which was of the yellow field sort, was sown on the same day. That sown on the ashes sprung much earlier than that on the dung, continued more vigorous during the season; and when I pulled them lately, the turnips produced from the ashes were more than double the size of those from the dung. I regret that I did not weigh the produce of each; but I have marked off a square chain of Swedish, which I mean to weigh, to ascertain the produce *per* acre. Excepting myself, no person has hitherto practised the burning of subsoil in this country, till last season, when I prevailed on Mr John Wallace, tenant of Mr Murray's farm of Clauchan, in Tongland parish, to

Effects.

Manures.

try the experiment. In consequence of some misunderstanding that had arisen between Mr Wallace and the former tenant, the latter, contrary to the usual practice, declined to sell to Mr Wallace the outgoing crop, and carried the whole off to the immediate adjoining farm, which he rented. Mr Wallace was thereby put to considerable inconvenience, having scarcely any fodder for his stock, and being thus deprived of the means of raising dung for his green crop. In his distress he applied to me, and I engaged for him a person to burn clay. Though it was the beginning of May before the burning commenced, yet Mr Wallace obtained as many ashes as manured twenty acres. Notwithstanding the turnips were later of being sown than usual, and were too long in being hoed, Mr Wallace obtained for them the second premium for green crop from the Agricultural Society in the stewartry; and since that time the Highland Society have awarded to him their first premium.

Quantity per Acre.

He laid on, at first, about forty-five single cart-loads to the acre, and diminished the quantity to thirty. I laid on, however, a much larger quantity; but I should imagine, that from forty to fifty cart-loads *per* acre would be a fair dose for our light soils. You, who have experienced the beneficial effects of ashes obtained by paring and burning the surface, can easily appretiate the value of ashes obtained from burning subsoil, and conceive the facility which they afford to the extension of the green crop system, to a breadth not hitherto contemplated. I may, however, mention, that this year, by means of ashes, I was enabled to raise three times the quantity of green crop that I had of white crop, and shall thus have it in my power to feed my cattle on turnip for more than six months, affording them, night and morning, as much as they are able to eat. Though my farm is, no doubt, of small extent, still this shows what may be done on a larger scale, where greater facilities can be obtained.

"Though I do not apprehend that any written account I can give you will afford half so satisfactory an idea of the method of burning clay, as ocular inspection of the work, yet I shall give you the best description I can.

Method of burning Clay or Subsoil.

"The general method of proceeding to work, is to make an oblong inclosure, of the dimensions of a small house, (say 15 feet by 10,) of green turf sods, raised to the height of $3\frac{1}{2}$ or 4 feet. In the inside of this inclosure, air-pipes are drawn diagonally, which communicate with holes left at each corner of the exterior wall. These pipes are formed of sods put on edge, and are so wide only as another sod can easily cover. In each of the four spaces left between the air-pipes and the outer wall, a fire is kindled with wood and dry turf, and then the whole of the inside of the inclosure, or kiln, is filled with dry turf, which is very soon on fire; and on the top of that, when well kindled, is thrown the clay, in small quantities at a time, and repeated as often as necessary, which must be regulated by the intensity of the burning. The air-pipes are of use only at first, because, if the fire burns with tolerable keenness, the sods forming the pipes will soon be reduced to ashes. The pipe on the weather-side of the kiln only is left open, the mouths of the other three being stopped up, and not opened unless the wind should veer about. As the inside of the inclosure, or kiln, begins to be filled up with clay, the outer wall must be raised in height, always taking care to have it at least eighteen inches higher than the top of the clay, for the purpose of keeping the wind from acting on the fire. When the fire burns through the outer wall, which it often does, particularly when the top is overloaded with clay, the breach must be stopped up *immediately*, which can only be effectually done by building another sod-wall from the foundation, opposite to it, the sods that formed that part of the wall being soon reduced to ashes. The wall may be raised as high as is convenient for throwing on the clay, and the kiln may be increased to any size, by forming a new wall when the previous one is burnt through. I have had kilns so wide, that a horse and cart might have turned in them; but, when they are so broad, it requires the workmen to walk on the top of them while laying on the clay, which I would not recommend, because, the more loosely the clay can be laid on, the more rapidly will it burn. I did not take all the trouble above stated with my kilns: having the advantage of a quantity of old moss-sticks, and tree-roots, which I split, I kindled a large parcel of them, and surrounded the fire with a quantity of dry turf, and, as soon as it was well kindled, I built round it a strong wall of sods, and went on adding to the fire, and sods to the outer walls, when necessary, till the kilns were so large as to contain upwards of one hundred loads of ashes.

"The principal secret in burning consists in having the outer walls made quite close and impervious to the external air, and taking care to have the top *always lightly*, but *completely*, covered with clay; because, if the external air should come in contact with the fire, either on the top of the kiln or through its sides, the fire will be very soon extinguished, or at least much weakened. In short, the kilns require to be attended nearly as closely as charcoal pits. Clay is much easier burnt than either moss or loam, as the latter, by crumbling down, are very apt to smother the fire, unless carefully attended to. No rule can well be laid down for regulating the size of the lumps thrown on the kiln, as that must depend on the state of the fire; but, on opening the heaps, I have always found all the lumps completely reduced to ashes, and some of them were thrown on larger than my head. Clay, no doubt, burns more readily if it be dug up and dried for a day or two before it be thrown on the kiln; but this operation is not necessary, as it will burn though thrown on *quite wet*. When put on *too* wet, however, the fire, if burning very intensely, is apt to reduce it to a cake-like substance, and thus to render it unfit for manure. After a kiln is fairly set a-going, no coal or wood, or any sort of combustible, is necessary, the wet clay burning of itself; and it can only be extinguished by intention, or the carelessness of the operator; the vicissitudes of the weather having hardly any effect on the fire, if properly attended to. It may, perhaps, be necessary to mention, that, when the kiln is burning with great keenness, a stranger to the operation may be apt to think that the fire is extinguished; if, however, any person, either through impatience, or

Manures. too great a curiosity, should insist on examining the interior of the kiln, he will certainly retard, and may possibly extinguish, the fire: for, as I mentioned before, the chief secret consists in keeping out the external air from acting *immediately* on the fire." (*Farmer's Magazine*, Vol. XVI.)

### 7. *Miscellaneous Articles.*

Moss and dung. In the article Agriculture, in the body of the work, there is an account of the compost of moss and farmyard dung, introduced into notice by Lord Meadowbank; and we have only farther to add in regard to it, that we have found it, in the course of our own experience, to be a most valuable manure. We shall now mention some of those numerous vegetable, animal and other substances, which, though not in general use as manures, are sometimes employed for that purpose, in particular situations.

Of the substances of vegetable or animal origin occasionally or locally applied in this way, the number is very great. Succulent plants. All *green succulent plants* add to the fertility of soils, when ploughed in: and it is by no means uncommon to cultivate buck-wheat and other plants expressly for this purpose. *Thistles, docks*, and other noxious weeds, which at any rate should be always cut down before forming their seeds, may be advantageously used as manure, and are sometimes mixed with farm-yard dung when laid out to ferment, in the manner already described. Rape cake. *Rape cake* is an excellent dressing for turnips, and is most economically applied when thrown into the soil at the same time with the seed.* Carcases of animals. By covering *dead animals* with five or six times their bulk of soil, mixed with one part of lime, and suffering them to remain for a few months, their decomposition impregnates the soil with soluble matters, so as to render the mass an excellent manure; and by mixing a little fresh quicklime with it, at the time of its removal, the disagreeable effluvia may be in a great measure destroyed.† Fish. *Fish* are well known to be a powerful manure, though the quantity should be limited. A full crop of turnips has been got from spoilt herrings, laid on before the winter ploughing, at the rate of twenty-five barrels to an acre.‡ Blubber. *Blubber* has been used with great success by Lord Somerville, mixed with clay, sand, or any common soil, so as to expose a large surface to the air,§ but it has been found injurious in some instances,‖ probably owing to its being applied too largely, as has happened in the case of fish, or from not having been combined with a sufficient quantity of soil. Currier's shavings, &c. The *refuse* of the different manufactures of *skin* and *leather* affords very useful manures,—such as the shavings of the currier, furriers' clippings, and the offals of the tan-yard and of the glue maker. Urine. The value of *urine* is well known. According to Sir H. Davy, it should be used as fresh as possible, but not without being diluted with water. Night soil. *Night soil* is a most powerful manure. The disagreeable smell may be destroyed by mixing it with quicklime. The Chinese mix it with one third of its weight of fat marl, make it into cakes, which are said to be a common article of commerce, and dry it by exposure to the sun.¶ Pigeon's dung. Next to this, in its fertilizing powers, is *pigeons' dung*, commonly used in a dry state as a top-dressing, at the rate of about twenty bushels to an acre.**

Limestone, gravel, &c. Manures of a mineral or fossil origin are also numerous. *Limestone gravel*, which abounds in Ireland, *chalk, pounded limestone, sea-shells*, and *shelly sand*, are all employed, some of them to a considerable extent, in much the same manner as lime; but their effect, though durable, is not so immediate. Gypsum. *Gypsum*, or sulphate of lime, is found in several parts of England, but its value as a manure does not appear to be yet clearly determined. It does not seem to operate by accelerating putrefaction;†† but it is supposed that lands which have ceased to bear good crops of clover or cultivated grasses, may be restored by being manured with gypsum, as it is found in considerable quantities in their ashes.‡‡ Soot. *Soot* is known to be an useful top-dressing, either by itself, or when mixed with earth and lime, in the proportion of one part soot, five parts earth, and one part lime,§§ but its effects are not lasting. Salt. *Common salt* is sometimes an useful manure.‖‖ Sleech. *Sleech* or *sea ooze*, containing animal and vegetable substances, with a large proportion of calcareous matter, affords a valuable dressing, increasing the staple of the soil to which it is applied, as well as its fertility. Mud. *Pond* and *river-mud*, mixed with lime, has been often applied with good effect. Schistus. Even *coal-sill* or *schistus*, has been used with much advantage by Mr Curwen and others, after being decomposed with lime, in the proportion of one part of the latter to six of the former.¶¶

Town dung. The great quantity of valuable manure obtained from large towns, is a mixture of almost all these ingredients; and what was formerly a nuisance is now a source of revenue to the inhabitants, and of fertility to the country around them.

Folding. In several districts, land is manured on the surface, by cattle and sheep confined in temporary folds. See the Chapter on LIVE STOCK, where the benefits of this practice will be inquired into. Its expediency is a question that cannot be determined without a reference to its effects on the animals themselves, as well as to the value of the manure.

## CHAP. II.

## OF LAND UNDER PERENNIAL HERBAGE, AND IN A STATE OF NATURE.

Natural Herbage, There are few tracts of any extent throughout Great Britain, if we except the shifting sands on some

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* Davy's *Agricultural Chemistry*, p. 281.
† Id. p. 288.
‡ Ibid. *and Gen. Rep. of Scotland*, Vol. II. p. 527.
§ Davy's *Agricultural Chemistry*, p. 289.
‖ *Farmer's Magazine*, Vol. XVI.
¶ Davy's *Agricultural Chemistry*, p. 298.
** Id. p. 299. *and Gen. Rep. of Scot.* Vol. II. p. 545.
†† Davy's *Agricultural Chemistry*, p. 331.
‡‡ Id. p. 332, 333.
§§ Id. p. 341, *and General Report of Scotland*, Vol. II. p. 543.
‖‖ *Communications to the Board of Agriculture*, Vol. IV.
¶¶ *Farmer's Magazine*, Vol. XIV. p. 286.

Grass Lands.

parts of the coast, that do not bear plants of one kind or other; and, having treated in the preceding chapter of crops raised by the labours of agriculture, it remains to consider those parts of our territory, which nature has clothed with plants, the spontaneous products of soil and climate, and to mention the purposes to which these tracts are applied, and the improvements of which they are susceptible.

In the earlier stages of society, the *cerealia*, used for the food of man, necessarily obtain the principal attention of the cultivator. Little or no labour is required to provide food for the few animals whose assistance he needs in his rude operations; and herds and flocks, which propagate around him without his care, find the means of subsistence, in those extensive wilds on which his feeble exertions have not yet materially encroached. Though he is chiefly indebted to these animals, at this period, both for his food and clothing, agriculture must have made considerable progress, before he attempts to supply their occasional wants, by improving their pastures, or cultivating plants expressly for their maintenance. Until the middle of the seventeenth century, neither roots nor herbage were cultivated for live stock in England, nor in Scotland till about a hundred years after. The only provision for their subsistence, during the long winters of our latitude, was natural herbage in the state of hay, commonly the produce of some marshy or humid soils, along with the straw of corn; and during summer, the natural pastures, too generally occupied in common, were thought to require and to admit of little or no improvement.

The only food of live-stock in the earlier stages of cultivation.

Progress towards cultivated crops for them.

It is not till the increase of population, and the extension of tillage to supply its wants, that, in consequence of successive encroachments on the range of the inferior animals, it becomes necessary at last, to allot a part of the cultivated land itself for raising their food. In most countries of Europe, it is not found profitable, even at this day, to cultivate herbage and roots to any extent for feeding cattle; and the same course of successive crops of corn, with which the earliest agriculturists every where began their labours, still prevails almost universally in the north of Europe; not because all the land is required for producing grain, but, on the contrary, because the demand of the population for grain is so limited, compared to the extent of the country, as to leave the far greater part in the possession of the inferior animals; which, in this case, can be brought to market, at a much lower price than would replace the charges of feeding them, on crops raised by means of aration.

Greater part of Britain still allotted to Live Stock.

Other causes than the scantiness of population have produced a similar effect, though in a much smaller degree, in Great Britain; and by far the larger part of our territory also, is still appropriated to the maintenance of live stock. A great portion of it, indeed, is incapable of being cultivated with any advantage; but meadows, pastures, and wastes, are spread over extensive tracts, that would yield cultivated crops in abundance, both for man and the inferior animals. Before concluding this article, we shall have occasion to notice what seem to be the causes of this state of things; but it is unquestionable, that, in the present circumstances of the country, a great deal of the most fertile land is employed more profitably for its owners and occupiers, under perennial herbage, than it could be under our most approved courses of tillage. In what respect the interest of the nation is concerned in this arrangement, this is not the place to inquire.

Grass Lands. || Meadows.

To give a concise view of the agricultural state of the land in Britain, not subjected to aration, we shall offer some observations on *Meadows*, on *Natural Pastures*, and on *Wastes*, in separate sections.

## Sect. I. Meadows.

Meadows.

By *meadows*, we understand all such land as is kept under grass chiefly for the sake of a hay crop, though occasionally, and at particular seasons of the year, it may be depastured by the domestic animals; and we usually include under this term the notion of a greater degree of moisture in the soil, than would be thought desirable, either for permanent pasture or lands in tillage. Where hay is in great demand, as near large towns, and especially if a good system of cropping be but little understood, a great deal of arable land, indeed, may be seen appropriated to hay crops; but the most valuable meadows are such as are either naturally rather moist, or that are rendered so by means of irrigation.

Very little Meadow in Scotland.

As the alternate and convertible systems of husbandry, before explained, prevail throughout all the lowlands of Scotland, there is little land in that country that deserves the name of meadow; though it is sometimes applied to marshy spots, not worth improving for tillage, which yield a quantity of coarse herbage to be made into hay, and are called *bog* meadows. The only natural hay grounds of much value in Scotland are to be found in the sheep-walks of the southern counties, where one or two small inclosures, near the farmer's or shepherd's dwelling-house, are commonly reserved for producing hay to feed the flocks during a deep snow; and as there is seldom much land in tillage in such places, the manure, made from a few horses and cows, is sometimes spread on the surface of these fields, though by no means according to any regular plan. To a very small extent, watered meadows have been tried in Scotland, but, from a general conviction of the superior advantages of cultivating herbage and roots, on all soils that can be made to produce them, and probably also owing to the less fertilizing qualities of the waters, even meadows of this kind are not likely ever to become of general importance there. The remarks which we mean to offer on this subject, must therefore be understood as applicable to the practice of England only.

Plants.

The indigenous plants of which meadow-grass consists, necessarily vary with the qualities of the soil. The most valuable are, the sweet-smelling vernal-grass, *(Anthoxanthum odoratum)*; perennial rye-grass, *(Lolium perenne)*; foxtail, *(Alopecurus pratensis)*; common meadow grass, *(Poa trivialis* and *Poa pratensis)*; and soft meadow grass *(Holcus lanatus)*. The *poas* compose the greater part of the celebrated Orcheston meadows near Salisbury, and of the no less productive meadows near Edinburgh. Of the *Agrostis stolonifera*, or Irish fiorin, lately brought into notice by Dr Richardson, we shall give some account in a separate article.

Fiorin.

Meadows.

Time of shutting up Meadows.

The period at which stock is excluded from meadows, in order that the grasses may rise for a hay crop, is different, according to the nature of the soil in regard to humidity, and the kind of stock with which the land is depastured. In some instances, the cattle are removed in November, while the sheep are continued on the ground till February. (*Middlesex Report*, p. 224.) In other places, the meadows are open to all kinds of stock from August to April (*Id.* p. 219.); and to sheep, even till May. (*Lincolnshire Report*, p. 196.)

Management.

In the judicious management of meadow lands, attention must be paid to prevent the stagnation of water and the growth of aquatic plants, and to extirpate fern, docks, thistles, and other weeds. Moss, in particular, often establishes itself on such lands, to the great injury of the valuable grasses, and can with difficulty be removed, even by the application of calcareous manures. Ant and mole hills also abound in meadows, and are too often so much neglected, as to render a large portion of the surface nearly unproductive. And in these, as in all other hay grounds, the preparatory operations for the scythe should always conclude with the use of a heavy roller.

The most important particulars in the management of meadow lands are, their improvement by irrigation, and by the application of manure. Of IRRIGATION we shall treat in a separate article.

Time of applying Manure.

With regard to the time at which manure should be applied, a great difference of opinion prevails among the farmers of England. In the county of Middlesex, where almost all the grass lands are preserved for hay, the manure is invariably laid on in October (*Middlesex Report*, p. 224), while the land is sufficiently dry to bear the driving of loaded carts without injury, and when the heat of the day is so moderated as not to exhale the volatile parts of the dung. Others prefer applying it immediately after the hay-time, from about the middle of July to the end of August, which is said to be the "good old time;" * and if that season be inconvenient, any time from the beginning of February to the beginning of April. † It is, however, too common a practice, to carry out the manure during frosty weather, when, though the ground is not cut up by the carts, the fertilizing parts of the dung are dissipated, and washed away by the snow and rains before they can penetrate the soil.

Different Kinds of Manure.

"There is scarcely any sort of manure that will not be useful when laid on the surface of grass grounds; but, in general, those of the more rich dung kinds are the most suitable for the older sort of sward lands; and dung in composition with fresh vegetable earthy substances, the more useful in the new lays or grass lands."—"In this district, it is the practice of the best farmers to prefer the richest dung they can procure, and seldom to mix it with any sort of earthy material, as they find it to answer the best in regard to the quantity of produce, which is the principal object in view; the cultivators depending chiefly for the sale of their hay in the London markets."—"It is the practice to turn over the dung that is brought from London in a tolerable state of rottenness, once chopping it well down in the operation, so as to be in a middling state of fineness when put upon the land. It is necessary, however, that it should be in a more rotten and reduced state when applied in the spring, than when the autumn is chosen for that purpose." (*Dickson's Practical Agriculture*, Vol. II. p. 915.)

Experiments.

Some very interesting experiments have been made with different kinds of manure, for the purpose of ascertaining their effects, both in regard to the quantity and quality of the produce, on different kinds of land. Fourteen lots, of half an acre of eight yards to the rod each, were thus manured, and the grass was made into hay, all as nearly alike as possible. The greatest weight of hay was taken from the lot manured with horse, cow, and butchers' dung, all mixed together, of each about an equal quantity. It lay in that state about two months; and was then turned over, and allowed to lie eight or ten days more, after which it was put on the land before it had done fermenting, and spread immediately. And to ascertain the quality of the produce of the different lots, a small handful from each was laid down on a dry, clean place, where there was little or no grass, and six horses were turned out to them, one after another. In selecting the lots, there seems to have been little difference of taste among the horses; and all of them agreed in rejecting two lots, one of which had been manured with blubber mixed with soil, and the other with soot,—in both instances laid on in the month of April preceding. (*Lancashire Report*, p. 130, *et seq.*)

Quantity of Manure.

"The proportion of manure that is necessary must, in a great measure, depend upon the circumstances of the land, and the facility of procuring it. In this district (near London) where the manure is of a very good and enriching quality, from its being produced in stables and other places where animals are highly fed; the quantity is usually from four or five to six or seven loads on the acre, such as are drawn by three or four horses, in their return from town on taking up the hay." (Dickson's *Practical Agriculture*, Vol. II. p. 916.)

At what Intervals applied.

Manure is laid on at intervals of time, more or less distant, according to the same circumstances that determine the quantity of it. Though there are some instances of hay grounds bearing fair crops every year during a length of years, without any manure, or any advantage from pasturage, except what the after grass has afforded; ‡ yet, in general, manure must either be allowed every third or fourth year, or the land depastured one year, and mown the other; "or what is better, depastured two years and mown the third." (*Northumberland Report*, p. 111.) A succession of hay crops, without manure or pasturage, on meadows not irrigated, is justly condemned by all judicious farmers, as a sure means of impoverishing the soil.

Hay-making.

The mode of converting this herbage into hay,

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* *Com. to Board of Agriculture*, Vol. IV. p. 138. † Dickson's *Practical Agriculture*, Vol. II. p. 915.

‡ Marshall's *Review of Reports to the Board of Agriculture*, p. 183, *Western Department*.

Meadows. being somewhat different from that which has been described in regard to clovers and rye grass, requires to be mentioned here. The farmers of Middlesex, who supply the metropolis with hay, are understood to manage this department of rural economy in a very perfect manner; and as a full account of their practice is given in the Report of that county, we shall present the substance of it in the writer's own words.

"*First day.* All the grass mown *before* nine o'clock in the morning, is tedded, (or spread), and great care taken to shake it out of every lump, and to strew it evenly over all the ground. Soon afterwards it is turned, with the same degree of care and attention; and if, from the number of hands, they are able to turn the whole again, they do so, or at least as much of it as they can, till twelve or one o'clock, at which time they dine. The first thing to be done after dinner, is to rake it into what are called *single* windrows, and the last operation of this day is to put it into grass-cocks.

"*Second day.* The business of this day commences with tedding all the grass that was mown the first day *after* nine o'clock, and all that was mown this day *before* nine o'clock. Next, the grass-cocks are to be well shaken out into staddles (or separate plats) of five or six yards diameter. If the crop should be so thin and light as to leave the spaces between these staddles rather large, such spaces must be immediately raked clean, and the rakings mixed with the other hay, in order to its all drying of a uniform colour. The next business is to turn the staddles, and after that to turn the grass that was tedded in the first part of the morning, once or twice, in the manner described for the first day. This should all be done before twelve or one o'clock, so that the whole may lie to dry, while the work-people are at dinner. After dinner, the first thing to be done is, to rake the staddles into *double* windrows; next, to rake the grass into *single* windrows; then the double windrows are put into bastard-cocks; and lastly, the single windrows are put into grass-cocks. This completes the work of the second day.

"*Third day.* The grass mown and not spread on the second day, and also that mown on the early part of this day, is first to be tedded in the morning; and then the grass-cocks are to be spread into staddles, as before, and the bastard-cocks into staddles of less extent. These lesser staddles, though last spread, are first turned, then those which were in grass-cocks; and next the grass is turned once or twice before twelve or one o'clock, when the people go to dinner as usual. If the weather has proved sunny and fine, the hay which was last night in bastard-cocks, will this afternoon be in a proper state to be carried; but if the weather should, on the contrary, have been cool and cloudy, no part of it probably will be fit to carry. In that case, the first thing set about after dinner, is to rake that which was in grass-cocks last night into double windrows, then the grass which was this morning spread from the swaths, into single windrows. After this the hay which was last night in bastard-cocks, is made up into full sized cocks, and care taken to rake the hay up clean, and also to put the rakings upon the top of each cock. Next, the double windrows are put into bastard-cocks, and the single windrows into grass-cocks, as on the preceding days.

"*Fourth day.* On this day the great cocks just mentioned, are usually carried before dinner. The other operations of the day are such, and in the same order, as before described, and are continued daily until the hay-harvest is completed.

"In the course of hay-making, the grass should, as much as possible, be protected both day and night against rain and dew, by cocking. Care should also be taken to proportion the number of hay-makers to that of the mowers, so that there may not be more grass in hand, at any time, than can be managed according to the foregoing proces. This proportion is about twenty hay-makers (of which number twelve may be women) to four mowers: the latter are sometimes taken half a day to assist the former. But in hot, windy, or very drying weather, a greater proportion of hay makers will be required, than when the weather is cloudy and cool.

"It is particularly necessary to guard against spreading more hay than the number of hands can get into cock, the same day, or before rain. In showery and uncertain weather, the grass may sometimes be suffered to lie three, four, or even five days in swath. But before it has lain long enough for the underside of the swath to become yellow (which if suffered to lie long would be the case), particular care should be taken to turn the swaths with the heads of the rakes. In this state, it will cure so much in about two days, as only to require being tedded a few hours, when the weather is fine, previous to its being put together, and carried. In this manner, hay may be made and stacked at a small expence, and of a good colour; but the tops and bottoms of the grass are insufficiently separated by it.

"There are no hay-stacks more neatly formed, nor better secured, than those of Middlesex. At every vacant time, while the stack is carrying up, the men are employed in pulling it with their hands into a proper shape, and about a week after it is finished, the whole of it is properly thatched, and then secured from receiving any damage from the wind, by means of a straw-rope, extended along the eaves, up the ends and near the ridge. The ends of the thatch are afterwards cut evenly below the eaves of the stack, just of sufficient length for the rain-water to drip quite clear of the hay. When the stack happens to be placed in a situation which may be suspected of being too damp in the winter, a trench of about six or eight inches deep is dug round, and nearly close to it, which serves to convey all the water from the spot, and renders it perfectly dry and secure." (*Middlesex Report*, p. 238-241.)

After-grass. When the grass has risen again, after the hay crop, it is usually depastured, as has been already mentioned when treating of clovers: to mow a second time is considered a bad practice among the best hay farmers. (*Middlesex Report*, p. 249.) But it is the usage of some to leave the after-grass on the ground without being eaten till spring, when it is said to be preferable, for ewes and lambs, to turnips, cabbages, or any other species whatever of what is

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termed *spring-feed*. This mode of management, which is strongly recommended by Mr Young, and in some cases by Mr Marshall also, is unknown in the north, where, though it is in many cases found beneficial, with a view to an early spring growth, not to eat the pastures too close before winter, it would be attended with a much greater loss of herbage, than any advantage in spring could compensate, to leave the after-growth of mown grounds untouched till that season. There has never been found any deficiency of milk, with ewes that are tolerably well supplied with turnips, a little before and after they drop their lambs.

The weight of the hay, produced on meadows well managed, being on an average about one ton and a half per acre, holds out little encouragement to retain good arable land in this condition; and, unless near London, and a few other large towns, pasturage would probably give a much more valuable return. In Lincolnshire, where there are some of the richest grazing lands in England, it is observed, that all lands that will feed cattle should be mown as little as possible; and nothing pays worse there than the scythe; "it costs as much labour as a crop of corn, and more than in many counties, and is not of half the value." (*Lincolnshire Report*, p. 195.)

## Sect. II. Pastures.

We have already mentioned, in the preceding chapter, that pasturage for one, two, or more years, is frequently interposed in the course of cropping arable land, to prevent that exhaustion of the soil which is commonly the consequence of incessant tillage crops. The pasture lands to be treated of here, are, therefore, such as are retained permanently, or at least for an indefinite period in this state, merely for the sake of the herbage they yield, and without any particular view to the amelioration of the lands, for bearing crops of grain. In this general application of the word, permanent pastures include not only such land as might be cultivated by the plough; but also all those uplands to which tillage operations could not be extended with any prospect of remuneration; such as the far greater part of the hilly and mountainous sheep grounds throughout this kingdom. The nature of these pastures is, however, so different, and the expediency of retaining *arable land* in permanent pasture has been so keenly discussed, that it will be proper to notice the two descriptions separately, under the general, though not quite accurate appellations, of *feeding* and *hilly* pastures. Under the former, we may comprehend all old rich pastures that are capable of *fattening* cattle; and under the second, such as are adapted to *rearing* them only, or are more advantageously depastured with sheep.

Permanent Pastures.

### 1. *Feeding-Pastures.*

Feeding-pastures.

Of these there is a great extent in most counties of England, but very few in Scotland, except near the houses of great proprietors; and much useless controversy has been carried on, between the farmers of the two countries, about the comparative advantages of preserving such pastures, or of bringing them under a regular system of alternate or convertible husbandry. That much of this land in the south would be more productive, both to the proprietor and occupier, under a good course of cropping than under pasture, it is impossible to deny; but it is no less certain, that there are large tracts of rich grazing land, which, in the present state of the demand for the produce of grass lands, and of the law of England with regard to tithes, cannot be employed more profitably for the parties concerned, than in pasture. The interest which the Board of Agriculture has taken in this question, with a view to an abundant supply of corn, for the wants of a rapidly increasing population, seems, therefore, not to have been well directed. Instead of devoting a large portion of their volumes to the instruction of farmers, regarding the best method of bringing grass lands into tillage, and restoring them again to meadow or pasture, without deterioration; the first thing required was, to attempt removing the almost insuperable obstruction of tithes, by proposing to the legislature an equitable plan of commutation. If some beneficial arrangement were adopted on this head, there is no reason to doubt, that individual interest would soon operate the wished for change; and that all grass lands capable of yielding more rent and profit under tillage than under pasture, would be subjected to the plough, as fast as the demands of the population might require.

Pastures.

Different opinions as to management.

Except in regard to those necessary operations that have been already noticed, under the former section,—such as the extirpation of weeds and noxious shrubs, clearing away ant and mole-hills, &c. there are few points respecting the management of this kind of land, on which some difference of opinion does not prevail. The time of stocking,—the number of the animals, and whether all should be of one or of different species,—the extent of the inclosures,—and the propriety of eating the herbage close, or leaving it always in a rather abundant state, are all of them questions which it is scarcely possible to decide in a satisfactory manner, by the application of general rules. They can only be resolved, with any pretensions to utility, by a reference to the particular circumstances of each case; for the practice of one district, in regard to these and other points, will be found quite inapplicable to others, where the soil and climate, and the purposes to which the pastures are applied, are materially different.

Manure.

It has been recommended to apply manure to grass lands, even where, not being used as hay grounds, they afford no means of supply. (Dickson's *Practical Agriculture*, Vol. II. p. 953.) But, excepting the dung dropped by the pasturing animals, which should always be regularly spread from time to time; it may be laid down as a rule of pretty extensive application, that if grass lands do not preserve their fertility under pasturage, it would be much better to bring them under tillage for a time, than to enrich them at the expence of land carrying crops of corn.

Teathing.

Another practice, which is scarcely less objectionable, is that of stacking on the field, or carrying to be consumed there during winter, the provender that ought to have furnished disposable manure for the

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use of the farm at large. It is to no purpose that such a wasteful practice is defended, on dry light soils, which are alleged to be thus benefited by the treading of the cattle. (Marshall's *Rural Economy of Yorkshire*, Vol. II. p. 131.) During the frequent and heavy falls of rain and snow in winter, there is scarcely any land so dry as not to be injured by the treading of heavy cattle; and were there anything gained in this respect by this management, it would be much more than counterbalanced by the loss of a great part of the manure, from the same cause. The able writer to whom we have just now referred, very properly disapproves of carting on manure in winter; and for the same reason,—namely, the loss of it which must necessarily be the consequence,—he ought to have objected to foddering on the land, or *teathing*, at that season. The practice, however, is but too common in those districts, both in South and North Britain, where the knowledge of correct husbandry has made but little progress. It is equally objectionable, whether the fodder be consumed on meadows where it grew, or on other grass lands. The fodder should, in almost every instance, be eaten in houses or fold-yards, instead of the dung being dropped irregularly over the surface; or, as must be almost always the case, accumulated in some spots sheltered by trees and hedges, to which the animals necessarily resort during the storms of winter.

Opening pastures in Spring.

The time of opening pastures in spring, must evidently be earlier or later, according to the climate, and in the same climate according to the season; and the state of growth, which it is desirable that the grass should attain, before being stocked, must in some degree be determined by the condition and description of the animals to be employed in consuming it,—whether they are only in a growing state, or approaching to fatness,—whether milk cows or sheep, or a mixture of animals of different species. It conveys no very precise idea respecting these points, though the remark itself is just, to say, that the herbage should not be allowed to rise so high as to permit the coarser plants to run to seed; and that it is bad management to suffer *store stock* to be turned upon a full bite. (Marshall's *Yorkshire*, Vol. II. p. 129.) The great objects to be aimed at are, that the stock, of whatever animals it may consist, should be carried forward, faster or slower, according to the purposes of their owner; and that no part of the herbage should be allowed to run to waste, or be unprofitably consumed. But nothing but careful inspection of the land and of the stock, from time to time, can enable any grazier to judge with certainty what are the best measures for attaining these objects.

" *Fatting cattle*," says Mr Marshall, " which are forward in flesh, and are intended to be finished with grass, may require a full bite at first turning out. But for *cows*, *working oxen*, and *rearing cattle*, and lean cattle intended to be fatted on grass, a full bite at the first turning out is not requisite." " Old lady-day to the middle of April, according to the progress of spring, appears to me, at present, as the best time for *shutting up mowing grounds* and *opening pastures*." (Marshall's *Yorkshire*, Vol. II. p. 152-3.)

State of growth when stocked.

In regard to the state of the growth of pastures when first stocked, some distinction should be made between new leys and old close swards. To prevent the destruction of the young plants, whether of clovers or other herbage, on the former description of pasture, which would be the consequence of stocking them too early, especially with sheep, they should be allowed to rise higher than would be necessary in the case of old turf; and to secure their roots from the further injury of a hot summer, it is advisable not to feed them close in the early part of the season, and probably not at any time throughout the whole of the first or second season, if the land is to be continued in pasture. The roots of old and firm sward, on the other hand, are not in so much danger, either from close feeding, or from the heats of summer; and they are in much less danger from the frosts and thaws of winter.

Stock.

Another circumstance almost equally indeterminate with the time of opening pastures, is the stock which should be employed; and whether they should be all of one or of different kinds.

With regard to the former, all soils rather moist, and of such a quality, as is the case with rich clays, as to produce herbage suited to the fattening of cattle, will, in general, be more advantageously stocked with them than with sheep; but there can be no other rule for the total exclusion of sheep, than the danger of the rot; nor any other general rule for preferring one kind of stock to another, than their comparative profits.

A mixed one preferred.

With regard to a mixed stock, the sentiments and practice of the best graziers seem to be in its favour. " It is generally understood that *horses* and *cattle* intermixed, will eat grass cleaner than either species will alone, not so much from their separately affecting different grasses, as from the circumstance of both species disliking to feed near their own dung." (Marshall's *Yorkshire*, Vol. II. p. 154.) " Some few graziers follow the old custom of keeping only one kind of stock upon the same ground, whilst others, we think, with more propriety, intermix, with oxen and cows, a few sheep, and two or three colts in each pasture, which both turn to good account, and do little injury to the grazing cattle. In some cases, sheep are a real benefit, by eating down and destroying the *ragwort (Senecio jacobœa)*, which disgraces some of the best pastures of the county, where *oxen only* are grazed." *(Northumberland Report*, p. 126.) And in Lincolnshire, where grazing is followed to a great extent, and with uncommon success, as well as in most other districts, the practice seems to be almost invariably, to keep a mixed stock of sheep and cattle on the same pasture, (*Lincolnshire Report*, p. 174), in proportions varying with the nature of the soil and the quality of the herbage.

Close and rough Feeding.

It is obviously impossible to estimate the number of animals that may be depastured on any given extent of ground, without reference to the particular spot in question; and the same difference exists, with regard to the propriety of feeding close, or leaving the pastures rough, that prevails in most other parts of this subject. Though there be loss in stocking too sparingly, the more common and dangerous error, is in overstocking, by which the summer's grass is not

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unfrequently entirely lost. There seems to us, however, to be a season, some time during the year, when grass lands, particularly old turf, should be eaten very close, not merely for the sake of preventing waste, but also for the purpose of keeping down the coarser kinds of plants, and giving to the pastures as equal and fine a sward as possible. The most proper period must partly depend upon the convenience of the grazier; but it can hardly be either immediately before the drought of summer, or the frost of winter. Some time in autumn, when the ardent heat of the season is over, and when there is still time for a new growth before winter, may be most suitable for the land itself, and generally also for the grazier, his fat stock being then mostly disposed of, or carried to the aftergrass of mown grounds. The *sweeping* of pastures, with the scythe, may be employed as a substitute for this close feeding; the waste and labour of which, however, though they be but trifling, it does not seem necessary to incur on rich grazing lands, under correct management.

Size of Inclosures.

The size of inclosures is a matter of considerable importance on grass-lands, both for the stock itself, and the mode of consuming the produce. In general, pastures best adapted to sheep should be in large fields. The animals are not only impatient of heat, and liable to be much injured by flies, in small pastures often surrounded by trees and high hedges, but they are naturally, with the exception perhaps of the Leicester variety, much more restless and easily disturbed than the other species of live stock. "Sheep," says a well known writer, "love a wider range, and ought to have it, because they delight in short grass: give them eighty or ninety acres, and any fence will keep them in; confine them to a field of seven or eight acres, and it must be a very strong fence that keeps them in." (*Kames's Gentleman Farmer*, p. 203.) Though fields so large as 80 or 90 acres, can be advisable only in hilly districts, yet the general rule is nevertheless consistent with experience, in regard to all our least domesticated varieties.

The size of fields deserves attention on another account; for there are strong reasons for preferring pasture land, in two or more inclosures, over the same extent in one large field. Besides the advantages of shelter, both to the animals and the herbage, such subdivisions enable the grazier, either to separate his stock into small parcels, by which means they feed more at their ease, or to give the best pastures to that portion of them which he wishes to come earliest to market. The advantages of moderate-sized inclosures are well known in the best grazing counties; but the subdivisions are in some instances, much more minute than is consistent with the value of the ground occupied with fences, or necessary to the improvement of the stock.

Succession of Stocks.

"In all cases," says Marshall "where fatting cattle or dairy cows make a part of the stock, and where situation, soil, and water will permit, every suit of grazing grounds ought, in my idea, to consist of *three compartments*. One for *head* stock (as cows or fatting cattle); one for *followers* (as rearing and other lean stock); and the third to be shut up to freshen, for the *leading* stock." (*Marshall's Yorkshire*, Vol. II. p. 158.)

It is sufficiently obvious, that every inclosure of pasture land should be provided with abundance of water at all times; though this is, in some districts, a matter of considerable difficulty. Mr Marshall has given a full account of the method of forming drinking pools, in Yorkshire; but our limits oblige us to refer the reader to his work. (*Id.* Vol. I. p. 146.)

### 2. *Hilly Pastures.*

Hill-pastures,

These include such low hills as produce fine short herbage, and are with much advantage kept constantly in pasture, though they are not altogether inaccessible to the plough; as well as such tracts as, from their acclivity and elevation, must necessarily be exclusively appropriated to live stock. The former description of grass lands, though different from the feeding pastures, of which we have just treated, in respect of their being less convenient for tillage management, are nevertheless in other circumstances so nearly similar, as not to require any separate discussion. These low hills are for the most part occupied with sheep, a very few cattle being sometimes depastured towards their bases; and they frequently comprise herbage sufficiently rich for fattening sheep, together with coarser pastures for breeding and rearing them. In many instances, a small part of such tracts is cultivated, chiefly for providing green crops for the sheep in winter; but corn is quite a subordinate object, and extensive aration is seldom attempted, except for the purpose of laying down the land to grass in an improved condition.

Improperly called wastes.

The more elevated pastures, from which the plough is altogether excluded, have been commonly classed among waste lands; even such of them as bear herbage by no means of inconsiderable value; as well as heaths and moors, with patches of which the green pastures are often chequered. The general term *wastes* is therefore a very indefinite expression; and, indeed, is not unfrequently made to comprehend all that extensive division of our territory that neither produces corn nor rich herbage. Yet it is on such tracts that by far the greater part of our butcher's meat and wool is grown, and not a little of the former fully prepared for the market. Foreigners and superficial readers at home, must accordingly be greatly mistaken, if they imagine that what are called *wastes*, by the Board of Agriculture, and other writers on Rural Economy, are really altogether unproductive; and it would be a still grosser error to believe, that all these wastes owe their continuance to neglect or mismanagement; and that any exertions of human industry can ever render the greater part of them, including all the mountainous tract of Great Britain, more valuable than they are at present, without a much greater expenditure of capital, than, under almost any circumstances, they could possibly return. Yet as this vague general term has been established by use, we shall bring together, in the following section, a few observations on the present condition of that part of our territory, which is still almost in a state of nature, and the improvements of which it is susceptible; referring to the body of the work for farther details. (AGRICULTURE, Part I. Sect. 2.)

Wastes.

## Sect. III. Wastes.

That part of Britain, which is still in a state of waste, might be treated of under a number of heads, corresponding to the various causes of its infertility.

Division of Wastes.

Land is comparatively unproductive, owing, 1*st*, To the surface being covered with stones, or occupied with worthless shrubs and other plants; 2*d*, To the superabundance of water, as in the case of mosses and marshes; 3*d*, To an original defect in the soil, as in loose sands, moors, and compact sterile clays, sometimes called *till;* 4*th*, To the elevation and ruggedness of the surface, and the ungenial character of the climate, as in our mountainous districts; 5*th*, To the previous exhaustion of the vegetable matter of the soil by injudicious cropping; and, 6*th*, To the mode of tenure and occupancy, as in commons.

Considerations as to their improvement.

It is matter of regret, that the subject of wastes has not yet been treated in that distinct and scientific manner, which its importance deserves. It would be advisable to have it ascertained, what portion of these divisions, or of others under which our wastes may be arranged, is capable of improvement, and how far such improvement is eligible, on a fair estimate of the cost, and the probable increase of produce. It should also be considered, as far as precision is attainable on such points, how much farther a proprietor might advantageously proceed in the expenditure of capital, than one who is merely a temporary occupier. For it is evident, that an improvement will be sufficiently profitable to the former, if he draws for his outlay four or five *per* cent yearly, whereas a tenant, holding on a lease of twenty years, must have an annuity for that period, of at least three times the amount, in order that his capital may be returned, with the ordinary profits of trade, before its expiration.

The delusive prospects of profit, from the improvement of wastes, held out by speculative men, have an unhappy tendency to produce disappointment in rash and sanguine adventurers, and ultimately to discourage such attempts as, with judicious attention to economy, would in all probability be attended with great success. Those who are conversant with the publications that have lately appeared on this subject, must be aware with what caution the alleged results of most of these writers ought to be examined; and how different has been the experience of those, who have ventured to put their schemes in practice, from what they had been led to anticipate.

There are few soils, however, so unfertile, and few tracts of any extent so destitute of soil, as not to be susceptible of profitable improvement, if the climate be not altogether hostile to vegetation, or the surface so steep or so rugged, as not to admit of any other operations than such as must be executed by manual labour. With this exception, and the exception probably of what is called *flow* moss—that *innabilis unda*, on which there is reason to fear much capital has been employed to little purpose,—wastes are certainly capable of considerable improvement, by surface or underdraining; by top-dressing with calcareous manures; by paring and burning as a preparation for tillage; by trenching, irrigation, and embankment.

Paring and burning.

The practice of paring and burning the surface of old swards, matted with the roots of coarse herbage and heath, is now generally acknowledged, both by scientific and practical writers, to be highly advantageous, as the next step in their cultivation after drainage. "The process of burning," says Sir Humphry Davy, "renders the soil less compact, less tenacious and retentive of moisture; and, properly applied, may convert a matter that was stiff, damp, and in consequence cold, into one powdery, dry, and warm; and much more proper as a bed for vegetable life.

"The great objection made by speculative chemists to paring and burning, is, that it destroys vegetable and animal matter, or the manure in the soil; but in cases in which the texture of its earthy ingredients is permanently improved, there is more than a compensation for this temporary disadvantage. And in some soils, where there is an excess of inert vegetable matter, the destruction of it must be beneficial; and the carbonaceous matter remaining in the ashes may be more useful to the crop than the vegetable fibre from which it was produced.

"Many obscure causes have been referred to for the purpose of explaining the effects of paring and burning; but I believe they may be referred entirely to the diminution of the coherence and tenacity of clays, and to the destruction of inert and useless vegetable matter, and its conversion into a manure.

For what lands proper.

"All soils that contain too much dead vegetable fibre, and which consequently lose from one-third to one-half of their weight by incineration, and all such as contain their earthy constituents in an impalpable state of division, *i. e.* the stiff clays and marls, are improved by burning; but in coarse sands, or rich soils containing a just mixture of the earths; and in all cases in which the texture is already sufficiently loose, or the organizable matter sufficiently soluble, the process of torrefaction cannot be useful.

"All poor siliceous sands must be injured by it; and practice is found to accord with theory. Mr Young, in his Essay on manures, states, 'that he found burning injure sand;' and the operation is never performed by good agriculturists upon siliceous sandy soils, after they have once been brought into cultivation." (*Agricultural Chemistry*, p. 346.)

Another mode of preparing waste land for tillage, though not calculated for being extensively employed during the present rate of wages, has been carried so far in Aberdeenshire, and apparently with so much success, as to deserve being noticed.

Trenching.

"The greater part of the land in the vicinity of Aberdeen has, from the most barren and unproductive state, been thoroughly improved by *trenching*. Not less than three thousand acres have been trenched within three miles of Aberdeen; and in all places of the county, considerable additions have been made to the arable, by trenching the barren lands."

"It is practised in barren land, which abounds in stones of different dimensions, sometimes, where the soil is dry, and in other cases, where it is wet, united with draining; it is practised when the object is to deepen the soil, or to mix a portion of the subsoil along with it; it is practised when the subsoil is tilly or very tenacious, as well as when that next the surface is unproductive, moory, or exhausted by overcropping. And, lastly, it is practised, when the land

Wastes. is foul, and when stronger or cleaner soil can be brought up to the surface.

"The expence indeed could not have been borne in many cases, if the first crop, (for so it may be called, as it covered the whole soil,) that was raised by the spade and mattock, had not produced from L. 30 to L. 50 *per* acre. This was a crop of granite stones, which was sold for paving the streets of London. But, after all, the ground that was thus gained to the community, would not have been able to recompence the cultivator, if a mixture of the spade and plough husbandry had not been introduced. The rent of the land in the immediate vicinity of Aberdeen, is extremely high; being now on a lease for years, from L. 5, to L. 10 *per* acre; and in a few cases, not less than L. 18; nay, when let for a single crop, sometimes as high as L. 20. Yet all this is necessary to remunerate the improver, who trenched, dunged, limed, and cultivated this thin soil, which must be frequently manured. It would have yielded too little produce, if tilled only by the plough; and would have been cultivated at too great an expence, if the soil had been constantly digged by the spade. A medium between these two, viz. either the alternate use of the plough and spade, or at least a mixture of plough and spade husbandry, was thus introduced by necessity, and has been attended with the happiest effects." (*Aberdeenshire Report.*)

Mr Roscoe's improvements on Chat moss.

We shall conclude these rather desultory observations, with some account of Mr Roscoe's very spirited and skilful operations in the reclaiming and improving of an extensive tract of moss, called Chat moss, in the county of Lancaster. The length of this moss is about six miles, its greatest breadth about three miles, and its depth may be estimated from ten to upwards of thirty feet. It is entirely composed of the substance well known by the name of peat, being an aggregate of vegetable matter, disorganized and inert, but preserved by certain causes from putrefaction. On the surface it is light and fibrous, but becomes more dense below. On cutting to a considerable depth, it is found to be black, compact, and heavy, and in many respects resembling coal. There is not throughout the whole moss the least intermixture of sand, gravel, or other material, the entire substance being a pure vegetable.

It is now upwards of twenty years since Mr Roscoe, in company with Mr Wakefield, began to improve Trafford moss, a tract of three hundred acres, lying two miles east of Chat moss; and his operations on it seem to have been so successful as to encourage him to proceed with Chat moss. But in the improvement of the latter, he found it unnecessary to incur so heavy an expence for drainage. From observing that where the moss had been dug for peat, the water had drawn towards it from a distance of fifty to a hundred yards, he conceived that if each drain had to draw the water only twenty-five yards, they would, within a reasonable time, undoubtedly answer the purpose. The whole of the moss was therefore laid out on the following plan.

Drainage.

"I first carried a main road," (says Mr Roscoe, in a recent communication to the Board of Agriculture), "nearly from east to west, through the whole extent of my portion of the moss. This road is about three miles long and thirty-six feet wide. It is bounded on each side by a main drain, seven feet wide and six feet deep, from which the water is conveyed, by a considerable fall, to the river. From these two main drains, other drains diverge, at fifty yards distance from each other, and extend from each side of the road to the utmost limits of the moss. Thus, each field contains fifty yards in front to the road, and is of an indefinite length, according as the boundary of the moss varies. These field-drains are four feet wide at the top, one foot at the bottom, and four feet and a half deep. They are kept carefully open, and, as far as my experience hitherto goes, I believe they will sufficiently drain the moss, without having recourse to underdraining, which I have never made use of at Chat moss, except in a very few instances, where, from the lowness of the surface, the water could not readily be gotten off without open channels which might obstruct the plough."

Cultivation.

The cultivation of the moss then proceeds in the following manner. "After setting fire to the heath and herbage on the moss, and burning it down as far as practicable, I plough a thin sod or furrow, with a very sharp horse-plough, which I burn in small heaps and dissipate: considering it of little use but to destroy the tough sods of the *Eriophora*, *Nardus sricta*, and other plants, whose matted roots are almost imperishable. The moss being thus brought to a tolerably dry and level surface, I then plough it in a regular furrow six inches deep; and as soon as possible after it is thus turned up, I set upon it the necessary quantity of marl, not less than two hundred cubic yards to the acre. As the marl begins to crumble and fall with the sun or frost, it is spread over the land with considerable exactness, after which I put in a crop as early as possible, sometimes by the plough, and at others with the horse-scuffle or scarifier, according to the nature of the crop, adding, for the first crop, a quantity of manure, which I bring down the navigable river Irwell to the borders of the moss, setting on about twenty tons to the acre. Moss land thus treated, may not only be advantageously cropped *the first year* with green crops, as potatoes, turnips, &c. but with any kind of grain; and as wheat has, of late, paid better to the farmer than any other, I have hitherto chiefly relied upon it, as my first crop, for reimbursing the expence."

Manures.

Expence and produce.

The expence of the several ploughings, with the burning, sowing, and harrowing, and of the marl and manure, but exclusive of the seed, and also of the previous drainage and general charges, amounts to L. 18, 5s. *per* acre; and in 1812, on one piece of land thus improved, Mr Roscoe had twenty bushels of wheat, then worth a guinea *per* bushel, and on another piece eighteen bushels; but these were the best crops upon the moss.

"Both lime and marl are generally to be found within a reasonable distance; and the preference given to either of them will much depend upon the facility of obtaining it. The quantity of lime necessary for the purpose is so small in proportion to that of marl, that, where the distance is great, and the carriage high, it is more advisable to make use of it;

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but where marl is upon the spot, or can be obtained in sufficient quantity at a reasonable expence, it appears to be preferable." Mr Roscoe is thoroughly convinced, after a great many different trials, that all temporizing expedients are fallacious; and "that the best method of improving moss-land is *by the application of a calcareous substance, in a sufficient quantity to convert the moss into a soil, and by the occasional use of animal or other extraneous manures*, such as the course of cultivation, and the nature of the crops, may be found to require."

There seems to be little more that is peculiar to himself in Mr Roscoe's operations, and course of cropping, except his contrivance for setting on the marl. It would not be practicable, he observes, to effect the marling at so cheap a rate, (L. 10 *per* acre,) were it not for the assistance of an iron road or railway, laid upon boards or sleepers, and moveable at pleasure. Along this road the marl is conveyed in waggons with small iron wheels, each drawn by one man. These waggons, by taking out a pin, turn their lading out on either side; they carry about 15 cwt. each, being as much as could heretofore be conveyed over the moss by a cart with a driver and two horses.

Railway.

Progress of MrRoscoe's Improvements.

In the month of November 1805, Mr Roscoe began the drainage, by cutting out the main drains on each side of the road; throwing out the moss from the drains into the middle of the road. In 1807, the smaller drains, at fifty yards distance from each other, were begun, and about one thousand acres laid out in the manner already mentioned. In 1808, part of the moss was sufficiently consolidated to be worked with horses in pattens; this year, a farm-house, with out-buildings, cottages, &c. were erected; and marl was set upon the land prepared for that purpose. About twenty acres were cropped, with turnips and potatoes, in 1809; and in the year following, upwards of eighty acres, of which twenty were wheat. In 1811, Mr Roscoe had one hundred acres in crop, chiefly in wheat; and in 1812, marl and street manure were applied in the quantities specified above. The crops were wheat and beans, which much surpassed those of any preceding year. "In the course of the present year, (1813,) I shall have brought into cultivation about one hundred and sixty acres, which will be cropped with wheat, oats, potatoes, and beans. A tract of thirty acres of clover appears to be very promising."

Improved Parts now laid into Meadow.

From a further communication, in May 1815, we learn that the depreciation of agricultural produce, and the difficulty of combining a regular course of cropping, with the bringing in of additional waste land, have induced Mr Roscoe to lay down the whole of the improved part of Chat moss into meadow land, which he had then nearly effected, and expected to accomplish in the course of the ensuing year. So long as land of this description continues productive in the state of meadow or pasture, it does not appear advisable to attempt any course of cropping whatever; and to lay it down for either of these purposes, ought perhaps to form the chief inducement to its improvement.

## CHAP. III.

## LIVE STOCK.

In the observations which we have to offer on this grand department of husbandry, which, in some quarters of the island, enjoys a decided preference over tillage, we shall treat, 1. Of Horses; 2. Of Cattle; 3. Of Sheep; 4. Of Swine; and, 5. Of Miscellaneous Stock.

### SECT. I. HORSES.

Form.

The form of a horse, peculiarly adapted to the labours of agriculture, has been well described by a writer of great experience and acute observation, in the following words:

"His head should be as small as the proportion of the animal will admit; his nostrils expanded, and muzzle fine; his eyes cheerful, and prominent; his ears small, upright, and placed near together; his neck, rising out from between his shoulders with an easy tapering curve, must join gracefully to the head; his shoulders, being well thrown back, must also go into his neck (at what is called the points) unperceived, which, perhaps, facilitates the going much more than the narrow shoulder; the arm, or fore-thigh, should be muscular, and, tapering from the shoulder, meet with a fine, straight, sinewy, bony leg; the hoof circular, and wide at the heel; his chest deep, and full at the girth; his loin or fillets broad and straight, and body round; his hips or hooks by no means wide, but quarters long, and tail set on, so as to be nearly in the same right line as his back; his thighs strong and muscular; his legs clean, and fine-boned; his leg-bones not round, but what is called lathy or flat." (Culley *on Live Stock*, p. 21.)

#### 1. *Breeds.*

Blacks.

1. The *black cart-horse*, bred in the midland counties of England (see Plate IX.), is better suited for drays and waggons than the common operations of a farm. The present system of farming requires horses of more mettle and activity, better adapted for travelling, and more capable of enduring fatigue, than those heavy sluggish animals. This variety is understood to have been formed, or at least brought to its present state, by means of stallions and mares imported from the Low Countries; though there appears to be some difference in the accounts that have been preserved, in regard to the places whence they were brought, and the persons who introduced them.* "The breed of grey rats," says Mr Marshall, "with which this island has of late years been overrun, are not a greater pest in it than the breed of black fen horses; at least while cattle remain scarce as they are at present, and while the flesh of horses remains to be rejected as an article of human food." (Marshall's *Yorkshire*, Vol. II. p. 164.) The present improved sub-variety of this breed is said to have taken its rise in six Zealand mares, sent over from the Hague by

* See Culley *on Live Stock*, p. 32. and Marshall's *Economy of the Midland Counties*, Vol. I. p. 306

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the late Lord Chesterfield, during his embassy at that Court.

Cleveland Bays.

2. The *Cleveland bays*, which owe some of their most valuable properties to crosses with the race-horse, have been long celebrated as one of the best breeds in the island; but they are said to have degenerated of late. They are reared to a great extent in Yorkshire, the farmers of which county are remarkable for their knowledge in everything that relates to this species of live stock. In activity and hardiness, these horses have perhaps no superior. Some capital hunters have been produced by putting full-bred stallions to mares of this sort; but the chief object latterly has been to breed coach-horses, and such as have sufficient strength for a two-horse plough. Three of these horses carry a ton and a half of coals, travelling sixty miles in twenty-four hours, without any other rest but two or three baits upon the road; and frequently perform this labour four times a-week.

Suffolk Punch.

3. A third variety is the *Suffolk Punch*, a very useful animal for rural labour. Their merit seems to consist more in constitutional hardiness than true shape. (See Plate IX.) "Their colour is mostly yellowish or sorrel, with a white ratch or blaze on their faces; the head large, ears wide, muzzle coarse, fore-end low, back long, but very straight, sides flat, shoulders too far forward, hind-quarters middling, but rather high about the hips, legs round and short in the pasterns, deep-bellied and full in the flank. Here, perhaps, lies much of the merit of these horses; for we know, from observation and experience, that all deep-bellied horses carry their food long, and, consequently, are enabled to stand longer and harder days' works. However, certain it is, that these horses do perform surprising days' works. It is well known, that the Suffolk and Norfolk farmers plough more land in a day than any other people in the island; and these are the kind of horses everywhere used in those districts." (Culley *on Live Stock*, p. 27.

Clydesdale.

4. The *Clydesdale* horse has been long in high repute in Scotland and the north of England; and, for the purposes of the farmer, is probably equal to any other breed in Britain. Of the origin of this race, various accounts have been given, but none of them so clear or so well authenticated as to merit any notice. They have got this name, not because they are bred only in Clydesdale or Lanarkshire,—for the same description of horses are reared in the other western counties of Scotland, and over all that tract which lies between the Clyde and the Forth,—but because the principal markets at which they are sold, Lanark, Carnwath, Rutherglen, and Glasgow, are situated in that district, where they are also preserved in a state of greater purity than in most other parts. They are rather larger than the Suffolk Punches, and the neck is somewhat longer; their colour is black, brown, or grey, and a white spot on the face is esteemed a mark of beauty. The breast is broad; shoulder thick, the blades nearly as high as the chine, and not so much thrown backwards as in road-horses; the hoof round, usually of a black colour, and the heels wide; the back straight and broad, but not too long; the hucks visible, but not prominent, and the space between them and the ribs short; the tail heavy, and well haired, the thighs meeting each other so near as to leave only a small groove for the tail to rest on. One most valuable property of this breed is, that they are remarkably true pullers, a restive horse being rarely found among them. See Plate X.

Welsh.

5. The *Welsh* horse bears a near resemblance, in point of size and hardiness, to the best of the native breed of the Highlands of Scotland, and other hilly countries in the north of Europe. It is too small for the present two-horse ploughs; but few horses are equal to them for enduring fatigue on the road. "I well remember one," says Mr Culley, "that I rode for many years, which, to the last, would have gone upon a pavement by choice, in preference to a softer road." (*Observations on Live Stock*, p. 35.)

Galloways.

6. A little horse, of much the same size with the former, or rather larger, called a *Galloway*, from its being found chiefly in that province of Scotland, has now become very rare; the breed having been neglected from its unfitness for the present labours of agriculture. The true Galloways are said to resemble the Spanish horses; and there is a tradition, that some of the latter, that had escaped from one of the vessels of the Armada, wrecked on the coast of Galloway, were allowed to intermix with the native race. Such of this breed as have been preserved in any degree of purity are of a light bay or brown colour, with black legs, and are easily distinguished by the smallness of their head and neck, and the cleanness of their bone.

Highland Ponies.

7. The still smaller horses of the Highlands and Isles of Scotland are distinguished from larger breeds by the several appellations of *Ponies*, *Shelties*, and in Gaelic of *Garrons*, or *Gearrons*. They are reared in great numbers in the Hebrides, or Western Isles, where they are found in the greatest purity. Different varieties of the same race are spread over all the Highland district, and the Northern Isles. This ancient breed is supposed to have been introduced into Scotland from Scandinavia, when the Norwegians and Danes first obtained a footing in these parts. "It is precisely the same breed that subsists at present in Norway, the Feroe Isles, and Iceland, and is totally distinct from every thing of horse kind on the continent of Europe, south of the Baltic. In confirmation of this, there is one peculiar variety of the horse in the Highlands that deserves to be noticed. It is there called the *eel-backed* horse. (See Plate X.) He is of different colours, light bay, dun, and sometimes cream-coloured; but has always a blackish list that runs along the ridge of the back, from the shoulder to the rump, which has a resemblance to an eel stretched out. This very singular character subsists also in many of the horses of Norway, and is nowhere else known." (Walker's *Hebrides*, Vol. II. p. 158.)

"The Highland horse is sometimes only nine, and seldom twelve hands high, excepting in some of the southern of the Hebrides, where the size has been raised to thirteen or fourteen hands by selection and better feeding. The best of this breed are handsomely shaped, have small legs, large manes, little neat heads, and are extremely active and hardy. The common colours are grey, bay, and black; the

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last is the favourite one." (*General Report of Scotland*, Vol. III. p. 176.)

2. *Breeding and Rearing.*

The same attention to select the best males and females for breeding, which has been productive of the most advantageous results in the case of cattle and sheep, does not prevail very generally in the breeding of farm-horses; on the contrary, though every one exercises some degree of judgment in regard to the stallion, there are few breeders, comparatively, who hesitate to employ very ill-formed and worthless mares,—and often solely because they are unfit for any thing else than bringing a foal. All the best writers on Agriculture reprobate this absurd and unprofitable practice. "In the midland counties of England, the breeding of *cart-horses* is attended to with the same assiduity as that which has of late years been bestowed on cattle and sheep; while the breeding of *saddle-horses*, *hunters*, and *coach-horses* is almost entirely neglected; is left almost wholly to chance, even in *Yorkshire*,—I mean as to females. A breeder here would not give five guineas for the best brood mare in the kingdom, unless she could draw or carry him occasionally to market; nor a guinea extraordinary for one which could do both. He would sooner breed from a rip, which he happens to have upon his premises, though not worth a month's keep. But how absurd! The price of the leap, the keep of the mare, and the care and keep of her progeny, from the time they drop to the time of sale, are the same, whether they be sold from ten to fifteen, or from forty to fifty pounds each." (Marshall's *Economy of Yorkshire*, Vol. II. p. 166.)

Inattention to the Female in Breeding.

Stallions.

In those districts where the breeding of horses is carried on upon a large scale, and upon a regular plan, the rearing of stallions forms in some degree a separate branch; and is confined, as in the case of bulls and rams, to a few eminent breeders. These stallions, which are shewn at the different towns in the vicinity,—sometimes sent to be exhibited at a considerable distance,—are let out for the whole season, or sold to stallion-men, or kept by the breeder himself, for covering such mares as may be offered, at a certain price per head; and this varies according to the estimation in which the horse is held, and sometimes according as the mare has more or less of what is called *blood*. For farm-mares, the charge for covering by a stallion of the same kind is commonly about a guinea, with half-a-crown to the groom; and it is a common practice in the North, to agree for a lower rate if the mare does not prove with foal; sometimes nothing more is paid in that case than the allowance to the groom.

Age of Breeding.

The age at which the animals should be allowed to copulate is not determined by uniform practice; and is made to depend, in some measure, on the degree of maturity, which, in animals of the same species, is more or less early, according to breed and feeding. Yet it would seem, in general, to be an improper practice, to allow animals to propagate, while they are themselves in a raw unformed state, and require all the nutriment which their food affords, for raising them to the ordinary size of the variety to which they belong. It may, therefore, be seldom advisable to employ the stallion till he is about three years old, or the mare till she is a year older. But the greater number of mares kept for breeding are much older than this; and are, in many cases, not allowed to bring foals till they are in the decline of life, or otherwise unable to bear their full share in rural labour.

Season.

In the breeding of horses, as in all other kinds of live stock, it is of importance that, at the season of parturition, there should be a suitable supply of food for the young. The time of covering mares ought, therefore, to be partly regulated by a due regard to this circumstance, and may be earlier in the South than in the North, where grass, the most desirable food both for the dam and foal, does not come so early by a month or six weeks. In Scotland, it is not advantageous to have mares to drop their foals sooner than the middle of April; and as the period of gestation is about eleven months, they are usually covered in May, or early in June. But if mares are intended to bring a foal every year, they should be covered from the ninth to the eleventh day after foaling, whatever may be the time; and the horse should be brought to them again nine or eighteen days afterwards.

Mares worked.

The mares are worked in summer as usual, and more moderately in the ensuing winter, till near the time of foaling; when, if the season be somewhat advanced, even though the pasture be not fully sufficient for their maintenance, they should be turned out to some grass field near the homestead, and receive what additional supply of food may be necessary under sheds adjoining. It is both inconvenient and dangerous to confine a mare about to foal in a common stable, and still more so, to leave her loose in a close stable among other horses; and confinement is not much less objectionable after dropping her foal. Such sheds are also exceedingly convenient, even after grass has become abundant, as the weather is often cold and rigorous during the month of May. When the foal is a few weeks old, the mare is again put to light work; and it is separated from the foal altogether, after having nursed it for about six months.

Breeding mares are evidently unable to endure the fatigue of constant labour, for some months before and after parturition. This has led a few farmers to rear foals upon cow milk; but the practice is neither common, nor likely ever to become so. The greater number of horses, therefore, are bred in situations where a small portion of arable land is attached to farms chiefly occupied with cattle or sheep; or where the farms are so small, as not to afford full and constant employment to the number of horses that must nevertheless be kept for the labour of particular seasons.

Foals.

"During the first winter, foals are fed on hay, with a little corn, but should not be constantly confined to the stable; for even when there is nothing to be got on the fields, it is much in their favour to be allowed exercise out of doors. A considerable proportion of succulent food, such as potatoes, carrots, and Swedish turnips (oil-cake has been recommended), should be given them through the first

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winter; and bean and peas meal has been advantageously substituted for oats, which, if allowed in a considerable quantity, are injurious to the thriving of the young animal, from their heating and astringent nature. Their pasture, during the following summer, depends upon the circumstances of the farms on which they are reared. In the second winter they are fed in much the same manner as in the first, except that straw may be given for some months instead of hay; and in the third winter, they have a greater allowance of corn, as they are frequently worked at the harrows in the ensuing spring, when about three years old." (*General Report of Scotland*, Vol. III. p. 183.)

System of Rearing.

The rearing of horses is carried on in some places in so systematical a manner, as to combine the profit arising from the advance in the age of the animals, with that of a moderate degree of labour, before they are fit for the purposes to which they are ultimately destined. In the ordinary practice of the midland counties, the breeders sell them while yearlings, or, perhaps, when foals, namely, at six or eighteen months old, but most generally the latter. They are mostly bought up by the graziers of Leicestershire, and the other grazing parts of that district, where they are *grown* among the grazing stock until the autumn following. At two years and a half old, they are bought up by the arable farmers or dealers of Buckinghamshire, Berkshire, Wiltshire, and other western counties, where they are broken into harness, and worked till they are five, or more generally six years old. At this age, the dealers buy them up again to be sent to London, where they are finally purchased for drays, carts, waggons, coaches, the army, or any other purpose for which they are found fit. (Marshall's *Economy of the Midland Counties*, Vol. I. p. 311.)

A similar mode of transferring young horses from hand to hand is common in the west of Scotland. The farmers of Ayrshire and the counties adjacent, who generally crop not more than one fourth, or, at most, one third, of their arable land, and occupy the remainder with a dairy stock, purchase young horses at the fairs of Lanark and Carnwath before mentioned,—work them at the harrows in the following spring when below two years old,—put them to the plough next winter at the age of two years and a half, and continue to work them gently till they are five years old, when they are sold again at the Rutherglen and Glasgow markets, at a great advance of price, to dealers and farmers from the south-eastern counties. A considerable number of horses, however, are now bred in the Lothians, Berwickshire, and Roxburghshire, the very high prices of late having rendered it profitable to breed them, even upon good arable land. But many farmers of these counties, instead of breeding, still prefer purchasing two and a half or three and a half year old colts, at the markets in the West Country, or at Newcastle fair in the month of October. They buy in a certain number yearly, and sell an equal number of their work-horses, before they are so old as to lose much of their value, so that their stock is kept up without any other loss than such as arises from accidents; and the greater price received for the horses they sell, is often sufficient to cover any such loss. (*General Report of Scotland*, Vol. III. p. 182.)

Castration.

Castration is performed on the males, commonly, when they are about a year old; but a late writer strongly disapproves of delaying this operation so long, and recommends *twitching* the colts, a practice well known to ram breeders, any time after they are a week old, or as soon after as the testicles are come down; and this method, he says, he has followed himself with great success. (Parkinson *on Live Stock*, Vol. II. p. 74.) Another writer suggests, for experiment, the *spaying* of mares, thinking they would work better and have more wind than geldings. (Marshall's *Yorkshire*, Vol. II. p. 169.) But he does not appear to have been aware, that this is by no means a new experiment; for Tusser, who wrote in 1562, speaks of *gelding fillies* as a common practice at that period. The main objection to this operation is not that brood-mares would become scarce, as he supposes, but that, by incapacitating them from breeding, in case of accidents and in old age, the loss on this expensive species of live stock would be greatly enhanced. An old or lame mare would then be as worthless as an old or lame gelding is at present.

### 3. *Feeding and Working.*

Age of working.

The age at which horses are put to full work, in the labours of a farm, is usually when four or five years old, according to the nature of the soil, and the numbers of the team; but they are always understood to be able to pay for their maintenance after they are three years old, by occasional work in ploughing and harrowing.

It is not so common a practice as it should be, to subject young horses of this kind to any regular course of training. But they are made familiar with their keeper as soon as they are weaned, led about in a halter, rubbed down in the stable, and treated with gentleness; and before being put to work, it is usual to place them under the charge of a steady, careful servant, who very soon learns them to drag a harrow alongside of an older horse, and afterwards to take their share of the labour at the plough; and, by degrees, in all the other work of the farm.

With regard to the mode of feeding and working them, and their treatment in general, the practice is so various, according to the state of agriculture in different districts, and the circumstances of their owners, that all that can be done here is, to mention some leading points of management, in which all good farmers are agreed.

Selection of Work-horses for different Purposes.

The selection of horses adapted to particular situations is evidently a matter of primary consideration. It has been already hinted, that the heavy black cart-horses, so much valued in London and a few other great towns, are but ill adapted to the operations of modern husbandry; and the nature of the soil and surface, and the situation of a farm in regard to markets, manure, and fuel, require some difference in the strength, activity, and hardiness of this instrument of labour. Accordingly, in the northern counties of Britain, where economy in this department is more attended to than in the south, we find horses of considerable strength, and a mode-

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rate share of activity, employed on firm, cohesive soils; and on light, friable soils, such as are possessed of more activity, not apt from their weight to be soon fatigued by working on an unequal surface, and able to endure travelling, with a moderate load, for a considerable distance, without injury.

Kept in good Condition.

Whatever may be the description of horses employed, it is always a rule with good managers, never to allow them to fall off in condition so much as to be incapable of going through their work, without frequent applications of the lash. There is nothing which more clearly marks the unprosperous condition of a tenant, than the leanness of his working cattle, and their reluctant movements under this severe stimulus. There are particular operations, indeed, such as turnip-sowing, seeding fallows, harvest work, &c. which require to be executed with so great dispatch, in our variable climate, that unusual exertions are often indispensable. At these times, it is hardly possible, by the richest food and the most careful treatment, to prevent the animals from losing flesh, sometimes even when their spirit and vigour are not perceptibly impaired. Such labours, however, do not continue long, and should always be followed by a corresponding period of indulgence. It is particularly dangerous and unprofitable, to begin the spring labour with horses worn down by bad treatment during winter.

Feeding.

Much has been said about the great expence of feeding horses on corn and hay, and various roots have been recommended as advantageous substitutes. That these animals can ever be made to perform their labour, according to the *present* courses of husbandry, on carrots, turnips, potatoes, or other roots alone, or as their *chief* food, our own experience and observation lead us to consider as very improbable. They will work and thrive on such food, but they will work as much more, and thrive as much better with oats or beans in addition, as fully to repay the difference in expence. One of the three meals a day, which farm-horses usually receive, may consist of roots; and a few of them, every twenty-four hours, are highly conducive to the health of the animals; but we have never had occasion to see any horse work regularly throughout the year, in the way they are usually worked in the best cultivated districts, without an allowance of at least an English peck of oats, or mixed oats and beans, daily, less or more at particular periods, but rather more than this quantity for at least nine months in the year.

It has been already observed, that machines are in some places used for cutting hay and straw into chaff, for bruising or breaking down corn, and for preparing roots and other articles by means of steam. The advantages of these practices, both in regard to the economy of food, and the health of the animals, are too evident to require illustration. But the custom, which has been adopted by a few individuals, and injudiciously recommended by others, of cutting down oats with their straw into the state of chaff, without being previously thrashed, is wasteful and slovenly in the extreme. The proportion, as to quantity or quality, which the oats bear to the bulk of the straw, being various in every season, and almost in every field, the proper allowance of oats can be served out only by first separating them from the straw, and then mixing them with the cut straw or chaff, in suitable proportions, before being laid into the manger.

Work performed.

The work performed is evidently a question of circumstances, which does not admit of any precise solution. It has been observed in the section on tillage, that a two-horse plough may, on an average, work about an English acre a-day throughout the year; and, in general, according to the nature of the soil, and the labour that has been previously bestowed on it, a pair of horses, in ploughing, may travel daily from ten to fifteen miles, overcoming a degree of resistance equal to from four to ten hundred weight. On a well made road, the same horses will draw about a ton in a two-wheeled cart for twenty or twenty-five miles every day; and *one* of the better sort, in the slow movement of the carrier or waggoner, commonly draws this weight by himself on the best turnpike-roads. In some places horses are in the yoke, when the length of the day permits, nine hours, and in others ten hours a day, but for three or four months in winter, only from five to eight hours. In the former season they are allowed to feed and rest two hours from mid-day, and in the latter they have a little corn on the field, when working as long as there is day-light, but none if they work only five or six hours.

In the section on farm-buildings, we have described with some minuteness the construction and interior arrangement of modern stables; and it is only necessary to add here, that the stable management of horses has been greatly improved of late years. It is not long since there were instances, even in the Border counties, of horses being turned loose into a stable, without racks or mangers, and without any other litter than the straw intended for their food, which they tossed about in all directions. Even those farmers who found it necessary to confine them to separate *stances*, did not see the advantage of separating them by partitions, but left them standing, as is too generally the case at present with cattle, at liberty to inflict, and exposed to endure serious injuries and privations. When at last they were confined in stalls, it was common to place two in each by way of saving room and the expence of partitions; and with the same view they were made to stand in double rows, one row on each gable or side-wall, the hind-legs of each row so near those of the opposite one as to leave little room for carrying away their dung without danger, and to afford little security against the attacks from behind of vicious horses, placed on the opposite sides of the stable. That all these inconveniences are avoided in the present stables, must be evident from the description already given, and the engraving there referred to.

Stable management.

It is now well understood that the liberal use of the brush and the currycomb twice a-day,—frequent but moderate meals, consisting of a due proportion of succulent joined to more solid food,—abundance of fresh litter, and great attention to method and cleanliness, are as indispensable in the stable of a farmer (as far as is consistent with a just regard to economy),

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as they have always been held to be in the treatment of horses kept for pleasure. Good dressing, with all well-informed and attentive men, is considered to be no less necessary to the thriving of the horses than good feeding; according to a common expression, it is equal to half their food. We shall conclude this section with an extract from a very recent publication, for the purpose of explaining the minutiæ of management adopted in the most improved counties of Scotland.

General management in Scotland.

"For about four months in summer, horses are fed on pastures; or on clover and rye-grass, and tares, cut green, and brought home to the stable or fold-yard; the latter method being by far the most economical and advantageous. For other eight months, they are kept on the straw of oats, beans and peas, and on clover and rye-grass hay. As soon as the grass fails towards the end of autumn, they have hay for a few weeks, and when the days become so short as to allow of no more than from six to eight hours work, they are very generally fed with different kinds of straw, according to the circumstances of the farm; in the month of March, they are again put to hay till the grass is ready for being cut. Throughout all the year they are allowed more or less corn, when constantly worked; and during the time they are on dry fodder, particularly when on straw, they have potatoes, yams, or Swedish turnips, once a day, sometimes boiled barley, and, in a few instances, carrots. A portion of some of these roots is of great importance to the health of horses, when succulent herbage is first exchanged for hay at the end of autumn; and it is no less so towards the latter end of spring, when hay has become sapless, and the labour is usually severe. At these two periods, therefore, it is the practice of all careful managers, to give an ample allowance of some of these roots, even though they should be withheld for a few weeks during the intermediate period.

"The quantity of these different articles of food must depend on the size of the horses, and the labour they perform; and the value upon the prices of different seasons, and in every season, on the situation of the farm with respect to markets, particularly for hay and roots, which bring a very different price near large towns, and at a few miles distant. It is for these reasons, that the yearly expence of a horse's maintenance has been estimated at almost every sum, from L. 15 to L. 40. But it is only necessary to attend to the expence of feeding horses that are capable of performing the labour required of them, under the most correct and spirited management. Such horses are fed with oats, sometimes with beans, three times a-day, for about eight months; and twice a-day for the other four, when at grass; and, at the rate of eight feeds per bushel, each horse will eat fifteen quarters of oats, or twenty bolls Linlithgow measure in the year. When on hay, he will require about one stone of twenty-two pounds *avoirdupois* daily, and five pounds more if he does not get roots. One English acre of clover and rye-grass, and tares, may be necessary for four months soiling; and a quarter of an acre of potatoes, yams, or Swedish turnips, during the eight months he is fed with hay or straw. The use of these roots may admit of a small diminution of the quantity of corn in the winter months, or a part of it may be, as it almost always is, of an inferior quality: but in many cases no such deduction is made, and the latter circumstance has been attended to in stating the price of the oats. The expence of feeding a horse throughout the year may therefore be estimated as follows:

Horses ‖ Cattle.

Annual expence of one Horse in food.

| | | | |
|---|---|---|---|
| Oats, 15 quarters at 25s. | L. 18 | 15 | 0 |
| Soiling, one acre of clover and rye-grass, and tares, | 7 | 10 | 0 |
| Hay part of October and November,—March, April, and May, 125 stones ($1\frac{1}{4}$ ton) at 10d. | 5 | 4 | 2 |
| Straw for other four months, half the price of hay, | 2 | 12 | 1 |
| Potatoes, yams, or Swedish turnips, $\frac{1}{4}$ acre, | 2 | 10 | 0 |
| | L. 36 | 11 | 3 |

"Supposing the land of a medium quality, the extent required for a horse's maintenance may be about five acres; that is, for oats three acres, soiling one, and one more for hay and roots. On rich soils four acres will be sufficient, but on poor soils, and wherever horses are kept at pasture, the produce of six acres and a half, or seven acres, will be consumed by one of them, when worked in the manner already mentioned. The straw of about two acres must be allowed for fodder and litter, the last of which has not been charged, because, at a distance from towns, what is allowed for litter must at any rate be converted into dung. If sixty acres, therefore, should be assumed as the average extent of land that may be kept in cultivation by two horses, according to the best courses of modern husbandry, the produce of ten acres of this will be required for their maintenance; or, a horse consumes the produce of one acre out of every six which he cultivates, according to a four or six years course, and something more than one acre out of every five which he ploughs annually." (*General Report of Scotland*, Vol. III. p. 192.)

According to the same writer, the annual expence of a pair of horses consists of the following sums:

Total expence of a pair of Horses.

| | | | |
|---|---|---|---|
| 1. Interest of purchase-money, decline in value, and insurance, | L. 15 | 12 | 0 |
| 2. Value of food, | 73 | 2 | 6 |
| 3. Harness, shoeing, and farriery, | 6 | 0 | 0 |
| | L. 94 | 14 | 6 |

besides the wages of the man who works them. (*General Report of Scotland*, Vol. III. p. 195.)

## SECT. II. CATTLE.

Variety of breeds of Cattle.

The purposes for which cattle are kept being more various, and cattle being also for the most part not so completely domesticated as horses, this species includes a much greater number of breeds and varieties. The different races have been distinguished

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generally by the length of their horns, or by their having no horns at all; and again subdivided, and more particularly described, under the names of the counties or districts where they are supposed to have originated, where they most abound, or where they exist in the greatest purity.

In Britain, as in most other countries, horses are useful only for the labour they perform, though it is probable that nothing but prejudice prevents them from enlarging, at least occasionally, the supply of human food; and to render them fit for labour, they must sooner or later in their lives be entirely subjected to the care and controul of man. Cattle, on the other hand, except the few kept for labour and for their milk, have not, till of late, (and even now only in particular countries), been the objects of that discipline and those experiments which seek to restrain habits acquired in a state of nature—to improve forms and proportions, perpetuated and somewhat varied by climate, surface, and herbage—and to cultivate and bring to perfection, with the greatest possible economy, all those valuable properties with which nature has endowed the inferior animals for the subsistence and the comfort of man. In most parts of the world cattle are still merely the creatures of soil and climate; and it is a striking evidence of the greater progress of social improvement in Britain, that we possess races of cattle and sheep, formed in a great measure by skill and industry, which excel beyond all comparison those of every other country.

ifferent oducts.

The three great products of cattle,—meat, milk, and labour, have each of them engaged the attention of British Agriculturists; but experience has not hitherto justified the expectation that has been entertained of combining all these desirable properties, in an eminent degree, in the same race. That form which indicates the property of yielding the most milk, differs materially from that which we know from experience to be combined with early maturity and the most valuable carcase; and the breeds which are understood to give the greatest weight of meat for the food they consume, and to contain the least proportion of offal, are not those which possess, in the highest degree, the strength and activity required in beasts of labour.

As we propose to treat of the produce and manufacture of milk in a separate article (See Dairy), we shall there have occasion to notice those breeds of which the females are the most valuable for the dairy; only referring at present to Plate X. for an engraving of the Ayrshire cow, an excellent race, spread over that and the counties adjacent. And as cattle are seldom or never reared exclusively, or even chiefly, for the purpose of labour, which is now in most parts of Britain performed entirely by horses, it will be sufficient, and as much as our limits will permit, just to touch on this point; and to apply our remarks, in an especial manner, to the races themselves, and the modes of treatment, which are best adapted to the production of beef.

"Whatever be the breed," says Mr Culley, "I presume that, to arrive at excellence, there is one form or shape essential to all, which form I shall attempt to give in the following description of a bull.

Form of the Male.

"The head of the bull should be rather long, and muzzle fine; his eyes lively and prominent; his ears long and thin; his horns white; his neck rising with a gentle curve from the shoulders, and small and fine where it joins the head; his shoulders moderately broad at the top, joining full to his chine and chest backwards, and to the neck-vane forwards; his bosom open; breast broad, and projecting well before his legs; his arms or fore thighs muscular, and tapering to his knee; his legs straight, clean, and very fine boned; his chine and chest so full as to leave no hollow behind the shoulders; the plates strong to keep his belly from sinking below the level of his breast; his back or loin broad, straight, and flat; his ribs rising one above another, in such a manner that the last rib shall be rather the highest, leaving only a small space to the hips or hooks, the whole forming a round or barrel-like carcase; his hips should be wide placed, round or globular, and a little higher than the back; the quarters (from the hip to the rump) long, and, instead of being square, as recommended by some, they should taper gradually from the hips backward, and the turls or pottbones not in the least protuberant; rumps close to the tail; the tail broad, well haired, and set on so high as to be in the same horizontal line with his back." (*Culley on Live Stock*, p. 38.)

1. *Breeds.*

Long-Horned.

1. The *Long-horned* or *Lancashire* breed of cattle is distinguished from others by the length of their horns, the thickness and firm texture of their hides, the length and closeness of their hair, the large size of their hoofs, and coarse, leathery, thick necks; they are likewise deeper in their fore-quarters and lighter in their hind-quarters than most other breeds,—narrower in their shape, less in point of weight than the short horns, though better weighers in proportion to their size; and though they give considerably less milk, it is said to afford more cream in proportion to its quantity.

They are more varied in their colour than any of the other breeds; but, whatever the colour be, they have in general a white streak along their back, which the breeders term *finched*, and mostly a white spot on the inside of the hough. (*Id.* p. 53.)

Improved Leicesters.

In a general view, this race, notwithstanding the singular efforts that have been made towards its improvement, remains with little alteration; for, excepting in Leicestershire, none of the subvarieties (which differ a little in almost every one of those counties where the long horns prevail) have undergone any radical change, nor any obvious improvement. The improved breed of Leicestershire is said to have been formed by Mr Webster, of Canley near Coventry, in Warwickshire, by means of six cows brought from the banks of the Trent about 90 years ago, which were crossed with bulls from Westmoreland and Lancastershire. Mr Bakewell, of Dishley, in Leicestershire, afterwards got the lead as a breeder, by selecting from the Canley stock; and the stocks of several other eminent breeders have been traced to the same source. (*Marshall's Midland Counties*, Vol. I. p. 318.) See Plate XI.

Short-Horned.

2. The *Short-horned*, sometimes called the Dutch

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breed, is known by a variety of names taken from the districts where they form the principal cattle-stock, or where most attention has been paid to their improvement. Thus, different families of this race are distinguished by the names of the *Holderness*, the *Teeswater*, the *Yorkshire*, *Durham*, *Northumberland*, and other breeds. The Teeswater breed, a variety of short-horns, established on the banks of the Tees at the head of the vale of York, is at present in the highest estimation, and is alleged to be the true Yorkshire short-horned breed. Bulls and cows from this stock, purchased at most extraordinary prices, are spread over all the North of England and the border counties of Scotland. The bone, head, and neck of these cattle are fine; the hide is very thin; the chine full; the loin broad; and the carcase throughout large and well fashioned; and the flesh and fatting quality equal, or perhaps superior, to those of any other large breed. The short-horns give a greater quantity of milk than any other cattle; a cow usually yielding 24 quarts of milk per day, making 3 firkins of butter during the grass season. Their colours are much varied; but they are generally red and white mixed, or what the breeders call *flecked*. See Plate XI.

"The heaviest and largest oxen of the short-horned breed, when properly fed, victual the East India ships, as they produce the thickest beef, which, by retaining its juices, is the best adapted for such long voyages. Our royal navy should also be victualed from these; but, by the jobs made by contractors, and other abuses, I am afraid our honest tars are often fed with beef of an inferior quality: however, the coal ships from Newcastle, Shields, Sunderland, &c. are wholly supplied with the beef of these valuable animals.

"These oxen commonly weigh from 60 to 100 stone (14lb. to the stone), and they have several times been fed to 120, 130, and some particular ones to upwards of 150 stone, the four quarters only." (*Culley on Live Stock*, p. 48.)

Middle-Horned.

The *Middle-horned* breeds comprehend in like manner several local varieties, of which the most noted are the *Devons*, the *Sussexes*, and the *Herefords*; the two last, according to Mr Culley, being varieties of the first, though of a greater size, the Herefords being the largest. These cattle are the most esteemed of all our breeds for the draught, on account of their activity and hardiness; they do not milk so well as the short-horns, but are not deficient in the valuable property of feeding at an early age, when not employed in labour.

Devons.

The *Devonshire* cattle are "of a high red colour (if any white spots, they reckon the breed impure, particularly if those spots run into one another), with a light-dun ring round the eye, and the muzzle of the same colour; fine in the bone, clean in the neck, horns of a medium length bent upwards, thin faced and fine in the chops, wide in the hips, a tolerable barrel, but rather flat on the sides, tail small and set on very high; they are thin skinned, and silky in handling, feed at an early age, or arrive at maturity sooner than most other breeds." (*Culley on Live Stock*, p. 51.) Another writer observes, that they are a model for all persons who breed oxen for the yoke. (*Parkinson on Live Stock*, Vol. I. p. 112.)

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The weight of the cows is usually from 30 to 40 stone, and of the oxen from 40 to 60. The north Devon variety, in particular, from the fineness in the grain of the meat, is held in high estimation in Smithfield. (*Dickson's Practical Agriculture*, Vol. II. p. 120.)

Sussex and Hereford.

The *Sussex* and *Hereford*-shire cattle are of a deep red colour, with fine hair and very thin hides; neck and head clean; horns neither long nor short, rather turning up at the points; in general they are well made in the hind quarters, wide across the hips, rump and sirloin, but narrow in the chine; tolerably straight along the back; ribs too flat; thin in the thigh; and bone not large. An ox, six years old, when fat, will weigh from 60 to 100 stone, the fore-quarters generally the heaviest. The oxen are mostly worked from three to six years old, sometimes till seven, when they are turned off for feeding. The Hereford cattle are next in size to the Yorkshire short-horns. Both this and the Gloucester variety are highly eligible as dairy stock, and the females of the Herefords have been found to fatten better at three years old than any other kind of cattle except the spayed heifers of Norfolk. (*Marshall's Economy of Gloucestershire*.)

Polled. Galloways.

4. The *Polled* or *hornless* breeds. The most numerous and esteemed variety is the Galloway breed, so called from the province of that name, in the south-west of Scotland, where they most abound. The true Galloway bullock "is straight and broad on the back, and nearly level from the head to the rump; broad at the loins, not, however, with hooked-bones, or projecting knobs, so that when viewed from above, the whole body appears beautifully rounded, like the longitudinal section of a roller. He is long in the quarters, but not broad in the twist. He is deep in the chest, short in the leg, and moderately fine in the bone, clean in the chop and in the neck. His head is of a moderate size, with large rough ears, and full, but not prominent eyes, or heavy eye-brows, so that he has a calm, though determined look. His well-proportioned form is clothed with a loose and mellow skin adorned with long soft glossy hair." (*Galloway Report*, p. 236.) The prevailing colour is black or dark-brindled, and, though they are occasionally found of every colour, the dark colours are uniformly preferred, from a belief that they are connected with superior hardiness of constitution. The Galloways are rather under-sized, not very different from the size of the Devons, but as much less than the long horns as the long horns are less than the short horns. On the best farms, the average weight of bullocks three years and a half old, when the greater part of them are driven to the south, has been stated at about forty stones *avoirdupois*. Some of them, fattened in England, have been brought to nearly one hundred stones. See Plate XII.

The general properties of this breed are well known in almost every part of England, as well as in Scotland. They are sometimes sent from their native pastures directly to Smithfield, a distance of 400 miles, and sold at once to the butcher; and in spring they are often shown in Norfolk, immediately after their arrival, in as good condition, or even better, than when they began their journey. With full feeding, there is perhaps no breed that sooner attains maturity,

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and their flesh is of the finest quality. Mr Culley was misinformed about the quantity of milk they yield, which, though rich, is by no means abundant.

"It is alleged not to be more than seventy or eighty years since the Galloways were all horned, and very much the same, in external appearance and character, with the breed of black-cattle which prevailed over the west of Scotland at that period, and which still abound in perfection, the largest sized ones in Argyllshire, and the smaller in the Isle of Skye. The Galloway cattle, at the time alluded to, were coupled with some hornless bulls, of a sort which do not seem now to be accurately known, but which were then brought from Cumberland; the effects of which crossing were thought to be the general loss of horns in the former, and the enlargement of their size: The continuance of a hornless sort being kept up by selecting only such for breeding, or perhaps by other means, as by the practice of eradicating with the knife the horns in their very young state." (Coventry *on Live Stock*, p. 28.)

The Galloway cattle, besides occupying almost exclusively the stewartry of Kirkcudbright and the shire of Wigton, the two divisions of Galloway, are now spread over the adjoining county of Dumfries; and are to be found, in smaller numbers, in most of the other districts of Scotland. The cattle of Angus or Forfarshire, on the east coast, many of which are also without horns, resemble the Galloways in their colour, size, and general properties.

Suffolk Duns.

The *Suffolk Duns*, according to Mr Culley, are nothing more than a variety of the Galloway breed. He supposes them to have originated in the intercourse that has long subsisted between the Scotch drovers of Galloway cattle, and the Suffolk and Norfolk graziers who feed them. The Suffolks are almost all light duns, thus differing from the Galloways, and are considered a very useful kind of little cattle, particularly for the dairy. *

Highlands.

5. The cattle of the Highlands of Scotland are divided into a number of local varieties, some of which differ materially from others, probably owing to a difference in the climate and the quality of the herbage, rather than to their being sprung from races originally distinct, or to any great change effected either by selection or by crossing with other breeds. It is only of late that much attention has been paid to their improvement, in any part of this extensive country; and in the northern and central Highlands the cattle are yet, for the most part, in as rude a state, and under management as defective, as they were some centuries ago.

These cattle have almost exclusive possession of all that division of Scotland, including the Hebrides, marked off by a line from the Frith of Clyde on the west to the Murray Frith on the north, and bending towards the east till it approaches in some places very near to the German ocean. Along the eastern coast, north of the Frith of Forth, the Highland cattle are intermixed with various local breeds, of which they have probably been the basis. There are more or less marked distinctions among the cattle of the different Highland counties; and, in common language, we speak of the Inverness-shire, the Banffshire, &c. cattle as if they were so many separate breeds; but it is only necessary in this place to notice the two more general varieties, now clearly distinguishable by their form, size, and general properties.

West Highlands, Argyllshire or Skye.

The most valuable of these are the cattle of the Western Highlands and Isles, commonly called the *Argyllshire breed*, or the breed of the Isle of Skye, one of the islands attached to the county of Inverness. The cattle of the Hebrides are called *Kyloes*, a name which is often applied in the south to all the varieties of the Highland cattle, not as a late writer (Dickson's *Practical Agriculture*, Vol. II. p. 1124.) has imagined, from the district in Ayrshire called Kyle, where very few of them are kept, but from their crossing, in their progress to the south, the *kyloes* or ferries in the mainland and Western Islands, where these cattle are found in the greatest perfection. (*General Report of Scotland*, Vol. III. p. 26.)

A bull of the Kyloe breed should be of a middle size, capable of being fattened to fifty stone avoirdupois. His colour should be black, or dark brown, or reddish brown, without any white or yellow spots. His head should be rather small, his muzzle fine, his horns equable, not very thick, of a clear green and waxy tinge; his general appearance should combine agility, vivacity, and strength; and his hair should be glossy, thick, and vigorous, indicating a sound constitution and perfect health. See Plate XII.

For a bull of this description, Mr Macneil of Colonsay lately refused 200 guineas; and for one of an inferior sort he actually received L. 170 Sterling. Mr Macdonald of Staffa bought one, nine years old, at 100 guineas. (*Report of the Hebrides*, p. 425.)

The lean weight of the best stock, from three to four years old, when they are commonly sold to the south, is from twenty-six to thirty stones the four quarters; but when brought to good pastures, they can be easily raised to fifty stones and upwards. There is perhaps no other breed whose weight depends so much on feeding; nor any that fattens and grows so much at the same time. They are exceedingly hardy, easily maintained, speedily fattened on pastures where large animals could scarcely subsist; the beef is fine in the grain, and well marbled or intermixed with fat; and their milk is rich, but small in quantity.

Norlands.

The other variety of Highland cattle is the *Norlands*, or North Highlanders, including the stocks of the counties of Ross, Cromarty, Sutherland, Caithness, and parts adjacent. Their hides are generally coarse; backs high and narrow; ribs flat; bones large; and legs long and feeble for the weight of the chest; and they are considered very slow feeders. But though this description be but too applicable to the cattle of the greater part of that remote district, considerable improvement has been effected in many parts of it, by crossing with the Skye or Argyll breeds, within the last twenty years.

Orkney and Zetland.

The cattle of the northern isles of Orkney and Zetland, are of a most diminutive size; an ox weigh-

* Culley *on Live Stock*, p. 66. and Parkinson *on Live Stock*, Vol. I. p. 118.

Cattle.

ing about sixty pounds a quarter and a cow forty-five pounds. They are of all colours, and their shapes are generally bad; yet they give a quantity of excellent milk; fatten rapidly when put on good pastures; and, in their own district, are considered strong, hardy, and excellent workers, when well trained to the yoke, and so plentifully fed as to enable them to support labour.

6. It has been already observed, that all along the lowlands of the eastern coast of Scotland, to the north of the Firth of Forth, there are varieties of cattle which, whatever may have been their origin, differ as much from the cattle of the western and northern Highlands, as most of those that have been described as separate breeds. Of the Fifeshire cattle, Mr Culley observes, "You would at first imagine them a distinct breed, from their upright white horns, being exceedingly light lyered and thin thighed, but I am pretty clear it is only from their being more nearly allied to the kyloes, and consequently less of the coarse kind of short horns in them." (Culley *On Live Stock*, p. 69.) Notwithstanding this opinion, the cattle of the north-eastern counties of Scotland require, for every useful purpose, to be mentioned separately from the Highland breeds; and as all of them have a general resemblance, it will only be necessary, in this place, to notice the Fife cattle in particular.

Fifeshire.

There are various traditions about the origin of this variety. It is said to have been much improved by English cows sent by Henry VII. to his daughter, the consort of James IV. who usually resided at the palace of Falkland in that county; and as there is some resemblance between the cattle of Fife and Cambridgeshire, they are supposed to have been brought originally from the latter county. Others ascribe the origin of the present breed to bulls and cows sent by James VI. (James I. of England), in payment of the money which his obliging neighbours in Fife are said to have advanced for his equipment, when he went to take possession of the English throne. (*Report of Nairn and Moray*, p. 305.)

The prevailing colour of the Fife cattle is black, though sometimes spotted or streaked with white, and some of them are altogether grey. The horns are small, white, generally pretty erect, or at least turned up at the points, bending rather forward, and not wide spread like the Lancashire long-horned breed. The bone is small in proportion to the carcase, the limbs clean but short, and the skin soft. They are wide between the hook-bones; the ribs narrow, wide set, and having a great curvature. They fatten quickly, and fill up well at all the choice points; are hardy, fleet, and travel well, and are excellent for labour, both at plough and cart. A good cow of this breed gives from eighteen to twenty-four quarts of milk *per* day, yielding from seven to nine pounds of butter, and from ten to twelve pounds of cheese *per* week, (twenty-four ounces to the pound), for some months after calving. (*Fife Report*, p. 251 and 253.)

Aberdeenshire.

The cattle of Aberdeenshire, the largest of which are said to have been produced by crossing with Fife bulls, have been long highly esteemed in the southern markets. It is observed, that every succeeding generation of them has increased in size, for the last thirty years; and that the native breed has doubled its former weight since the introduction of turnips. (*Aberdeenshire Report*, p. 468.) The colour is commonly black, but there are many of a red and brindled colour. They are thinner in the buttock, in proportion to their weight; and deeper in the belly, in proportion to their circumference, than the west Highlanders, and they yield a much larger quantity of milk. Many of them are brought to the south of Scotland, and kept during winter in the straw yards, for which they suit better than smaller cattle, as they are not so impatient of confinement. The ordinary weight of middle-sized oxen, at from three to five years old, is from forty to fifty stones; but after being worked for some time, and thoroughly fattened, they have been known to reach double this weight.

Welsh.

7. Of the *Welsh* cattle "there seem to be two distinct kinds. The large sort are of a brown colour, with some white on the rump and shoulders, denoting a cross from the long horns, though in shape not the least resembling them. They are long in the legs, stand high according to their weight, are thin in the thigh, and rather narrow in the chine; their horns are white and turned upwards; they are light in flesh, and next to the Devons, well formed for the yoke; have very good hoofs, and walk light and nimble. The other sort are much more valuable; colour black, with very little white; of a good useful form, short in the leg, with round deep bodies; the hide is rather thin, with short hair; they have a likely look and a good eye; and the bones, though not very small, are neither large nor clumsy; and the cows are considered good milkers." (Parkinson *on Live Stock*, Vol. I. p. 135.)

Alderney.

8. The *Alderney* cattle are to be met with only about the seats of a few great landholders, where they are kept chiefly for the sake of their milk, which is very rich, though small in quantity. This race is considered by very competent judges as too delicate and tender, to be propagated to any extent in Britain, at least in its northern parts. Their colour is mostly yellow or light red, with white or mottled faces; they have short crumpled horns, are small in size, and very ill shaped; yet they are fine boned in general; and their beef, though high coloured, is very well flavoured. I have seen, says Mr Culley, some very useful cattle bred from a cross between an Alderney cow and a short horned bull.

Wild breed.

9. The last variety of cattle we shall mention is the *wild* breed, which is found only in the parks of a few great proprietors, who preserve the animals as a curiosity. Those kept at Chillingham Castle in Northumberland, a seat belonging to the Earl of Tankerville, have been very accurately described in the *Northumberland Report*, and in Mr Culley's book on *Live Stock*, so often quoted in this article.

Colour.

"Their colour is invariably of a creamy white; muzzle black; the whole of the inside of the ear, and about one-third of the outside, from the tips downward, red; horns white, with black tips, very fine, and bent upwards; some of the bulls have a thin upright mane, about an inch and a half, or two inches long. The weight of the oxen is from thirty-five to

Weight.

Cattle.

forty-five stone, and the cows from twenty-five to thirty-five stone the four quarters (fourteen pound to the stone). The beef is finely marbled, and of excellent flavour.

"From the nature of their pasture, and the frequent agitation they are put into by the curiosity of strangers, it is scarce to be expected they should get very fat; yet the six-years-old oxen are generally very good beef, from whence it may be fairly supposed that, in proper situations, they would feed well.

Habits.

"At the first appearance of any person they set off in full gallop, and, at the distance of about two hundred yards, make a wheel round and come boldly up again, tossing their heads in a menacing manner; on a sudden they make a full stop, at the distance of forty or fifty yards, looking wildly at the object of their surprise, but, upon the least motion being made, they all again turn round, and fly off with equal speed, but not to the same distance, forming a shorter circle, and again returning with a bolder and more threatening aspect than before; they approach much nearer, probably within thirty yards, when they again make another stand, and again fly off: this they do several times, shortening their distance, and advancing nearer and nearer, till they come within such a short distance, that most people think it prudent to leave them, not choosing to provoke them farther.

Ancient hunting.

"The mode of killing them was perhaps the only modern remains of the grandeur of ancient hunting. On notice being given that a wild bull would be killed on a certain day, the inhabitants of the neighbourhood came mounted and armed with guns, &c. sometimes to the amount of an hundred horse, and four or five hundred foot, who stood upon walls or got into trees, while the horsemen rode off the bull from the rest of the herd, until he stood at bay, when a marksman dismounted and shot. At some of these huntings, twenty or thirty shots have been fired before he was subdued. On such occasions, the bleeding victim grew desperately furious, from the smarting of his wounds, and the shouts of savage joy that were echoing from every side. But, from the number of accidents that happened, this dangerous mode has been little practised of late years, the park-keeper alone generally shooting them with a rifled gun at one shot.

Calves.

"When the cows calve, they hide their calves for a week or ten days in some sequestered situation, and go and suckle them two or three times a day. If any person come near the calves, they clap their heads close to the ground, and lie like an hare in form, to hide themselves. This is a proof of their native wildness, and is corroborated by the following circumstance that happened to the writer of this narrative (Mr Bailey of Chillingham), who found a hidden calf, two days old, very lean and very weak. On stroking its head it got up, pawed two or three times like an old bull, bellowed very loud, stepped back a few steps, and *bolted* at his legs with all its force; it then began to paw again, bellowed, stepped back, and bolted as before; but knowing its intention, and stepping aside, it missed him, fell, and was so very weak, that it could not rise, though it made several efforts;—but it had done enough:—the whole herd were alarmed, and, coming to its rescue, obliged him to retire; for the dams will allow no person to touch their calves, without attacking them with impetuous ferocity.

"When a calf is intended to be castrated, the park-keeper marks the place where it is hid, and when the herd are at a distance, takes an assistant with him on horseback; they tie a handkerchief round the calf's mouth to prevent its bellowing, and then perform the operation in the usual way, with as much expedition as possible. When any one happens to be wounded, or is grown weak and feeble through age or sickness, the rest of the herd set upon it and gore it to death." (Culley *on Live Stock*, p. 73.)

### 2. *Breeding and Rearing.*

Great attention to breeding.

The pedigrees of the best cattle have been preserved with no less care, in several parts of England, than those of race-horses; and in the selection of breeders, the properties of the family from which they have descended, are matters of scarcely less importance than the form of the young animals themselves. In rearing calves, the *blood* and the *colour* seem to be more attended to by breeders in general, than the form. (Marshall's *Yorkshire*, Vol. II. p. 203.) The extraordinary prices paid for the best bred bulls and cows, show that this attention has not been without its reward.

Bulls.

The best bulls are either let out for the season, or cows are brought to them at a certain rate per head. The practice of *letting* bulls is said to have originated with Mr Bakewell (Marshall's *Midland Counties*, Vol. I. p. 334), who, so far back as 1792, let a bull for one hundred and fifty-two guineas, to be used only four months (Parkinson *on Live Stock*, Vol. II. p. 469); and five guineas *per* cow were about that time commonly paid to him and other eminent breeders.

Age of breeding.

The age at which bulls should begin to be employed, and the number of seasons they should be allowed to serve, as well as the age at which the females should begin to breed, are points regarding which practice is by no means uniform. In the Midland counties, the bulls are pretty commonly allowed to leap while yearlings, and if good stock-getters are kept on as long as they will do business, perhaps till they are ten or twelve years old. In other places they are employed only three seasons, for the first time at two years old. The females in many instances bring their first calf at the age of two years, but more commonly, perhaps, not till they are a year older; and in some of the Highland districts, where, owing to a want of proper nourishment in their infancy, they are later in reaching their full growth, the females do not often become mothers till they are about four years old.

Period of gestation.

The period of gestation with cows has been found, upon an average of a great number of experiments, to be about forty weeks; and they seldom bring more than one calf at a birth. When they produce twins, one of them a male and the other a female, the latter, which is called a *free martin*, is commonly considered to be incapable of procreation. Yet there seem to have been well authenticated instances to the contrary. (*Farmer's Magazine*, Vol. VII. p. 462, and Vol. VIII. p. 466.)

Free Martins.

Calves.

Though calves are dropped at all seasons of the

Cattle.

year, the spring is the most common period; and, except in those districts where the fatting of calves is an object of importance, it is probably the most advantageous time; as the calves, having all the grass season before them, become sufficiently strong for enduring the change to a less agreeable food in the ensuing winter. A calf newly weaned seldom thrives well during that period, unless it is pampered with better food than usually falls to the share of young animals.

Suckling.

In Galloway, and the Highlands of Scotland, the almost invariable practice is to allow the calves to suck the cows, and this commonly as long as the cows give any milk; most of them, indeed, will not give down their milk unless the calf is put to one side of the udder, while the milk-maid draws the teats on the other side; and if the maid gives the least interruption to her rival, the cow punishes the fraud by a blow with her leg, often overturning both the offender and the milking-pail. (*General Report of Scotland*, Vol. III. p. 47.) Where there is not an inclosure for confining the calves, when they are put to grass, a muzzle is made for the nose, with iron pikes fastened on it, which prick the cow when the calf attempts to suck at forbidden times, and obliges her to keep it off, till the muzzle be removed at the stated periods of milking. But this is too troublesome where many of them are reared, which are therefore kept apart from the cows till the hours of milking.

This natural method of rearing calves is common, at least for a short time, in other parts of Britain. Bull calves, and sometimes high bred heifers, are suffered to remain at the teat, until they be six, nine, or perhaps twelve months old; letting them run either with their dams, or more frequently, especially when the dairy is an object, with less valuable cows or heifers, bought in for the purpose; and when the intention is fulfilled, sold or fatted; each cow being generally allowed one male calf or two females.

Rearing calves.

"The best method of the dairymen is this:—The calves suck a week or a fortnight, *according to their strength* (a good rule); new milk in the pail, a few meals:—next, new milk and skim milk mixed, a few meals more: then, skim milk alone: or porridge, made with milk, water, ground oats, &c. and sometimes oil-cake,—until cheese-making commence; after which, whey porridge, or sweet whey, in the field; being careful to house them in the night, until warm weather be confirmed." (Marshall's *Midland Counties*, Vol. I. p. 338.)

This method of suckling is not however free from objection, and, in the ordinary practice of rearing calves, it is held to be a preferable plan to begin at once to learn them to drink from a pail. The calf that is fed from the teat must depend upon the milk of its dam, however scanty or irregular it may be; whereas, when fed from a dish, the quantity can be regulated according to its age; and various substitutes may be resorted to, by which a part of the milk is saved for other purposes, or a greater number of calves reared upon the same quantity. (*General Report of Scotland*, Vol. III. p. 51.) Yet it would seem to be a good practice to allow calves to suck for a few days at first, if there was no inconvenience to be apprehended both to themselves and their dams, from the separation afterwards.

Fed from a pail.

Quantity of Milk allowed.

When fed from the pail, the average allowance to a calf is about two English wine gallons of milk daily, for twelve or thirteen weeks; at first fresh milk as it is drawn from the cow, and afterwards skim-milk. But after it is three or four weeks old, a great variety of substitutes for milk are used in different places, of which lintseed, oil-cake, meal, and turnips, are the most common. The practice, however, varies so much, no particular substitute being in general use, nor the quantity, nor the time of giving it, accurately determined, that there is no need to add any thing to what has been already stated on this head in the principal article. (Part III. Sect. 3.) For the feeding and treatment of fattening calves, see DAIRY, in this Supplement.

Castration.

It is a rule, applicable to all kinds of live stock, to perform castration, where that is to be done, while the animals are yet very young, and just so strong as to endure this severe operation without any great danger of its proving fatal. The males, accordingly, are cut commonly when about a month old, and the females at the age of from one to three months; but in Galloway, where more heifers are *spayed* than perhaps in all the island besides, this is seldom done till they are about a year old.

Young Cattle.

The treatment of young cattle, from the time they are separated from their dams, or able to subsist on the common food of the other stock, must entirely depend upon the circumstances of the farm on which they are reared. In summer, their pasture is often coarse, but abundant; and in winter, all good breeders give them an allowance of succulent food along with their dry fodder. The following description is not less applicable to the best practice in the rearing of all cattle bred on arable land, than to the *short horns*:

"The first winter they have hay and turnips; the following summer coarse pasture; the second winter straw in the fold-yard, and a few turnips once a day, in an adjoining field, just sufficient to prevent the straw from binding them too much; the next summer tolerable good pasture; and the third winter as many turnips as they can eat, and in every respect treated as fatting cattle." (Culley *on Live Stock*, p. 47.) The only difference is, that, where straw is in great abundance, the cattle sometimes do not eat their turnips on the fields, but in the fold-yard. In those situations where turnips cannot be extensively cultivated, or where cattle are sold for grazing, instead of being fattened, a smaller allowance of turnips the third winter is made to suffice.

### 3. *Working*.

Working Cattle.

As the arguments for and against the use of cattle in farm-labour have been already detailed in the principal article, (Part III. Sect. 1.), we shall not now attempt any minute calculations, on a question of too general a nature to be decided by any number of references which our limits could allow. Almost the only change since that article was written, in the state of the argument, is, that four, or even three oxen, are now alleged to be capable of performing the

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work of two horses, instead of six or eight, the number formerly thought necessary. But it is a material circumstance in favour of those who contend for the superior advantages of horses, that, notwithstanding this more powerful reason for the use of oxen, horses have prevailed more and more;—that teams of the former are now rare with rent-paying farmers, wherever the most approved courses of husbandry prevail;—and that, in some of our best cultivated counties, not a single ox-team is to be found.

It may well be presumed from these simple facts, which cannot be disputed by the warmest advocates for oxen, that their general employment, recommended, indeed, chiefly by men of little or no experience, must be inconsistent with the present state of agriculture in Britain. The arguments drawn from the husbandry of the Greeks and Romans, and the modern practice of different parts of the world, will have very little more weight with the enlightened farmers of Britain, in regard to the working of oxen, than they would have, if brought forward to prove the superiority of manual and animal labour, in thrashing and other operations, over the employment of machinery. In addition to the arguments detailed in the article referred to, the reader may consult, upon this much-agitated question, some observations annexed to the last edition of Kames's *Gentleman Farmer.*

### 4. *Fatting.*

Different Kinds of Food used in fatting Cattle.

Cattle are fatted on grass in summer, commonly on pastures, but in a few instances on herbage cut and consumed in feeding-houses or fold-yards; and in winter, by far the greater number are fatted on turnips, along with hay or straw. Oil-cake, carrots, potatoes, and other articles of food, are used occasionally, and in particular districts; oil-cake chiefly for feeding the larger animals; but few comparatively are fatted on any of these without the addition of turnips, of one or other of the varieties formerly mentioned. (See Sect. VI.) A considerable number of cattle are also fatted on the offals of distilleries, when working from corn;—a source of supply, the frequent interruption of which, of late years, has been much felt in those situations where the soil does not permit the extensive cultivation of turnips.

Given in Houses or Fold-yards.

It is seldom or never the practice of the best managers to fatten cattle with roots or other winter food on the field, during that season; but to confine them to houses or fold-yards, where they are well littered, regularly fed, not liable to be disturbed, and sheltered from the inclemency of the weather, and where the manure they make is an object of very considerable importance, and of much greater value than if it were dropped at random over a whole field.

Age of fatting.

The age at which cattle are fatted depends upon the manner in which they have been reared; upon the properties of the breed in regard to a propensity to fatten earlier or later in life; and on the circumstances of their being employed in breeding, in labour, for the dairy, or reared solely for the butcher. In the latter case, the most improved breeds are fit for the shambles when about three years old, and very few of any large breed are kept more than a year longer. As to cows and working oxen, the age of fatting must necessarily be more indefinite; in most instances the latter are put up to feed after working three years, or in the seventh or eighth year of their age.

In general, it may be said, that the small breeds of cattle are fattened on pastures, though sometimes finished off on a few weeks' turnips; and that large cattle, at least in the north, are chiefly fatted in stalls or fold-yards, by means of turnips, and the other articles before mentioned.

Stall-feeding.

Stall-feeding is the most common, and, when judiciously conducted, probably the most eligible method, in regard to the cattle themselves, the economy of food, and the expence of farm-buildings. The small shed and fold-yard, called a *hammel*, are used only for the larger breeds; but they do not seem well calculated for an extensive system of fatting by those who do not breed, but purchase stock every year from different parts. (See Chap. I. Sect. II.)

Cattle Trade.

Cattle, it is well known, have long been the staple produce of Scotland, and since the union of South and North Britain, immense numbers have been carried every year to the feeding pastures and markets of England. But besides this transportation, so beneficial to both parts of the island, cattle often change their pastures and their owners before leaving Scotland, according to arrangements which, though not conducted with all the uniformity of system, are found to be very advantageous to the individuals concerned, and ultimately to the public at large.

"The Highland cattle often pass through three different hands, or more, before they come to the butcher. They are improved at every stage, by a greater quantity and better quality of food, instead of being suddenly transported from poor to rich feeding; and, while each successive owner applies his produce to the best advantage, and receives a suitable return according to its value, from the advance of price, the consumer at last purchases his beef cheaper, and of a better quality, than if the cattle had been sent to the shambles from any of the intermediate stages.

"The West Highland cattle make this progress oftener than the larger cattle of the north-eastern counties. Many of them are brought to Dumbartonshire and other places, at the age of two years and two years and a half, wintered on coarse pastures, with a small allowance of bog hay or straw, and moved to lower grounds next summer. They are then driven farther south, where they get turnips in straw-yards through the following winter, and in April are in high condition for early grass, upon which they make themselves fat in the month of June.

"The larger varieties of the north-eastern counties do not leave the breeder at so early an age. They are seldom brought to market till they are three, or three years and a half old, and then frequently in good condition for being fattened, either on grass or turnips. A great many of the Aberdeenshire cattle are bought for the straw-yards of the southern counties, get a few turnips through winter and spring, and are either driven to England in April, or fattened at home in the course of the en-

Cattle || Sheep.

suing summer. The Fife cattle, like the other breeds of the Lowlands, are generally sold to the graziers at three years old, having got a liberal allowance of turnips during the preceding winter. (*General Report of Scotland*, Vol. III. p. 84.)

Desiderata.

Notwithstanding the high degree of perfection to which some breeds of cattle have been brought in England, and the great attention that is paid by the most eminent breeders to every part of their management, several interesting points are not by any means clearly ascertained. Much certainly remains to be known regarding the nutriment afforded by different kinds of herbage and roots,—the quantity of food consumed by different breeds, in proportion as well to their weight at the time, as to the ratio of their increase,—and the propriety of employing large or small animals in any given circumstances. Even with regard to the degree of improvement made by fatting cattle generally, from the consumption of a given weight of roots or herbage, no great accuracy is commonly attempted; machines for weighing the cattle themselves and their food, from time to time, not being yet in general use in any part of Britain.

## Sect. III. Sheep.

Varieties of Sheep, numerous.

This species, being still more than cattle exposed to all the influences of soil and climate, displays a much greater variety in form, size, and general properties. In different counties, though the breed be originally the same, a very perceptible difference is found in all these respects; and there are not unfrequently considerable variations among the flocks of the same district, even those of contiguous farms. Yet in other situations, where rich food is abundantly supplied at all times of the year, sheep have been more highly improved than any other animals; and the breeds most esteemed for the arable land of Britain are in a great measure the creatures of the industry and sagacity of man. Hardly any two animals are more unlike than the small dun-faced sheep, supposed to be the most ancient of the kind in Britain, and the Leicester or Dishley male, whose every point must be exactly formed, according to an established model of symmetry and usefulness.

The various breeds of sheep, and the modes of management, almost as numerous as these varieties, would require a much larger space for their description, than it is possible to allot to it in a section of this article. But this branch has been already treated at some length in the body of the work (See Agriculture *Index*, and the Article Sheep, Vol. XIX.), and we shall therefore confine ourselves at present to the more prominent and interesting parts of the subject.

According to one writer (Culley *on Live Stock*, p. 102), there are fourteen different breeds of sheep in Great Britain, all of them sufficiently distinguished by their horns, or by being hornless, by the colour of their faces and legs, and by the length and quality of their wool. To these a later writer adds two varieties more (Dickson's *Practical Agriculture*, Vol. II. p. 1135); but a third work, still more recent (Parkinson *on Live Stock*, Vol. I. p. 249), enumerates no fewer that thirty-seven breeds, to each of which are assigned one or more characteristic peculiarities. This great diversity renders it necessary to decline a particular description of each: perhaps the most eligible mode of classification would be, to consider separately those races which are best adapted to inclosed arable land; those which occupy green hills, downs, and other tracts of moderate elevation; and, finally, such as inhabit the higher hills, and mountains. On the first description of land, every sort of practicable improvement may be effected, though there the carcase has hitherto been the chief object; on the second, the carcase is smaller but the wool generally finer,—and it is probably with such sheep that the greatest improvements ought to be attempted on the fleece; and, on the last division, the breeds are necessarily small and hardy, and, in regard to form and general properties, still almost in a state of nature. The improvement of sheep must mainly depend on the circumstances of every district, in regard to the food and shelter it affords them; and it is only where these indispensable requisites are abundantly provided by nature, or by human industry, that the most skilful management can be successful. The sheep of the rugged, heathy mountains of the Highlands of Scotland, must ever retain the form, the size, and the habits which the uncontrollable influence of their situation has impressed on them.

Sheep.

Mode of Classification.

But this mode of classification is more applicable to the general management adopted on the several sorts of land, than to the present breeds themselves, which are found intermixed in every district, and often even on the same field. We shall therefore in this, as in the two former sections, describe the distinguishing characteristics of the principal breeds as concisely as possible.

There is, however, in the case of sheep, as of all the other kinds of live stock, a certain form,—a sort of standard established by experience and observation of the best individuals,—to which it is wished that all the breeds of this species should approach. Mr Culley, to whom we have so often referred, as being by far the most skilful of our writers on live stock, thus describes the best form of a ram:

Form of the Male.

"His head should be fine and small, his nostrils wide and expanded, his eyes prominent, and rather bold or daring, ears thin, his collar full from his breast and shoulders, but tapering gradually all the way to where the neck and head join, which should be very fine and graceful, being perfectly free from any coarse leather hanging down; the shoulders broad and full, which must at the same time join so easy to the collar forward, and chine backward, as to leave not the least hollow in either place; the mutton upon his arm, or fore-thigh, must come quite to the knee; his legs upright, with a clean fine bone, being equally clear from superfluous skin and coarse hairy wool from the knee and hough downwards; the breast broad and well forward, which will keep his fore-legs at a proper wideness; his girth or chest full and deep, and, instead of a hollow behind the shoulders, that part by some called the fore-flank should be quite full; the back and loins broad, flat, and straight, from which the ribs must rise with a fine circular arch; his belly straight, the

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quarters long and full, with the mutton quite down to the hough, which should neither stand in nor out; his twist deep, wide, and full, which, with the broad breast, will keep his four legs open and upright; the whole body covered with a thin pelt, and that with fine, bright, soft wool.

"The nearer any breed of sheep comes up to the above description, the nearer they approach towards excellence of form." (Culley *on Live Stock*, p. 103.)

1. *Breeds.*

Breeds.

The sheep suited to arable land, in addition to such properties as are common in some degree to all the different breeds, must evidently be distinguished for their quietness and docility,—habits which, though gradually acquired and established by means of careful treatment, are more obvious, and may be more certainly depended on, in some breeds than in others. These properties are not only valuable for the sake of the fences by which the sheep are confined, but as a proof of the aptitude of the animals to acquire flesh in proportion to the food they consume.

The long-woolled large breeds (the varieties usually preferred on good grass lands), differ much in form and size, and in their fatting quality, as well as in the weight of their fleeces. The principal are, the *Lincoln*, the *Tees-water*, and the *Dishley*, or *New Leicester*.

In some instances, with the Lincolns in particular, wool seems to be an object paramount even to the carcase; with the breeders of the Leicesters, on the other hand, the carcase has always engaged the greatest attention: but neither form nor fleece separately is a legitimate ground of preference; the most valuable sheep being that which returns, for the food it consumes, the greatest marketable value of produce.

Lincolns.

The *Lincolnshire breed* have no horns, the face is white, and the carcase long and thin; the ewes weighing from 14 to 20lb., and the three-year-old wethers, from 20 to 30lb. per quarter. They have thick, rough, white legs, bones large, pelts thick, and wool long,—from ten to eighteen inches,—weighing from 8 to 14lb. per fleece, and covering a slow-feeding, coarse-grained carcase of mutton.

This kind of sheep cannot be made fat at an early age except upon the richest land, such as Romney-marsh, and the rich marshes of Lincolnshire; yet the prodigious weight of wool which is shorn from them every year, is an inducement to the occupiers of the marsh lands to give great prices to the breeders for their hogs or yearlings; and though the buyers must keep them two years more, before they get them fit for market, they have three clips of wool in the meantime, which of itself pays them well in those rich marshes. Not only the midland counties, but also Yorkshire, Durham, and Northumberland, can send their long-woolled sheep to market at two years old, fatter in general than Lincolnshire can at three. Yet this breed, and its subvarieties, are spread through many of the English counties.

Tees-water.

The *Tees-water* breed differ from the Lincolnshire in their wool not being so long and heavy; in standing upon higher, though finer boned legs, supporting a thicker, firmer, heavier carcase, much wider upon their backs and sides; and in affording a fatter and finer-grained carcase of mutton: the two-year-old wethers weighing from 25 to 35lb. per quarter. Some particular ones, at four years old, have been fed to 55lb. and upwards.

There is little doubt that the Tees-water sheep were originally bred from the same stock as the Lincolnshire, but, by attending to size rather than to wool, and constantly pursuing that object, they have become a different variety of the same original breed. (Culley *on Live Stock*, p. 122.)

"The present fashionable breed is considerably smaller than the original species; but they are still considerably larger and fuller of *bone* than the Midland breed. They bear an analogy to the short-horned breed of cattle, as those of the Midland counties do to the long-horned. They are not so compact, nor so complete in their form, as the Leicestershire sheep; nevertheless, the excellency of their flesh and fatting quality is not doubted, and their wool still remains of a superior staple. For the banks of the Tees, or any other rich fat-land country, they may be singularly excellent." Marshall's *Yorkshire*, Vol. II. p. 221.) Rams of this kind have been employed of late, in Northumberland and Berwickshire, in crossing ewes of the Leicester breed; but with what success there has not yet been time to determine.

New Leicesters.

The *Dishley*, or *New Leicester* breed is distinguished from other long-woolled breeds by their clean heads, straight, broad, flat backs, round barrel-like bodies, very fine small bones, thin pelts, and inclination to make fat at an early age. This last property is most probably owing to the before-specified qualities, and which, from long experience and observation, there is reason to believe, extends through every species of domestic animals. The Dishley breed is not only peculiar for its mutton being fat, but also for the fineness of the grain, and superior flavour, above all other large long-woolled sheep, so as to fetch nearly as good a price, in many markets, as the mutton of the small Highland and short-woolled breeds. The weight of ewes, three or four years old, is from 18 to 26lb. a quarter, and of wethers, two years old, from 20 to 30lb. The wool, on an average, is from 6 to 8lb. a fleece. (Culley *on Live Stock*, p. 106.) See Plate XIII.

Devonshire Nots.

A fourth hornless variety of long-woolled sheep is the *Devonshire Nots*, having white faces and legs, thick necks, narrow backs, and back-bone high; the sides good, legs short, and the bones large; weight much the same as the Leicesters, wool heavier, but coarser. In the same county, there is a small breed of long-woolled sheep, known by the name of the *Exmoor* sheep, from the place where they are chiefly bred. They are horned, with white faces and legs, and peculiarly delicate in bone, neck, and head; but the form of the carcase is not good, being narrow and flat sided. The weight of the quarters and of the fleece about two-thirds that of the former variety.

Exmoor.

The shorter woolled varieties, and such as, from their size and form, seem well suited to hilly and inferior pastures, are also numerous. Generally speak-

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ing, they are too restless for inclosed arable land, on the one hand, and not sufficiently hardy for heathy mountainous districts, on the other. To this class belong the breeds of *Dorset*, *Hereford*, *Sussex*, *Norfolk*, and *Cheviot*.

Dorsets.

The *Dorsetshire* sheep are mostly horned, white-faced, stand upon high small white legs, and are long and thin in the carcase. The wethers, three years and a half old, weigh from 16 to 20 lb. a quarter. The wool is fine and short, from 3 to 4 lb. a fleece. The mutton is fine grained and well flavoured.

This breed has the peculiar property of producing lambs at almost any period of the year, even so early as September and October. They are particularly valued for supplying London and other markets with house-lamb, which is brought to market by Christmas, or sooner if wanted, and, after that, a constant and regular supply is kept up all the winter.

Wilts.

According to Mr Culley, the *Wiltshire* sheep are a variety of this breed, which, by attention to size, have got considerably more weight, viz. from 20 to 28 lb. a quarter. These, in general, have no wool upon their bellies, which gives them a very uncouth appearance.

"The variations of this breed are spread through many of the southern counties, as well as many in the west, viz. Gloucestershire, Worcestershire, Herefordshire, &c.; though some of them are very different from the Dorsetshire, yet they are, I apprehend, only variations of this breed, by crossing with different tups; and which variations continue northward until they are lost amongst those of the Lincolnshire breed." (Culley *on Live Stock*, p. 131.)

Herefords.

The *Herefordshire* breed is known by the want of horns, and their having white legs and faces, the wool growing close to their eyes. The carcase is tolerably well formed, weighing from 10 to 18 lb. a quarter, and bearing very fine short wool, from $1\frac{1}{2}$ to $2\frac{1}{2}$ lb. a fleece: the mutton is excellent.

Cotting.

The store or keeping sheep are put into cots at night, winter and summer, and in winter foddered in racks with peas-straw, barley-straw, &c. and in very bad weather with hay. These cots are low buildings, quite covered over, and made to contain from one to five hundred sheep, according to the size of the farm or flock kept. The true Herefordshire breed are frequently called *Ryeland* sheep, from the land formerly being thought capable of producing no better grain than rye, but which now yields every kind of grain. See Plate XIII.

South Downs.

The *South Down* sheep are without horns; they have grey faces and legs, fine bones, long small necks; are low before, high on the shoulder, and light in the fore-quarter; the sides are good, and the loin tolerably broad, back-bone too high, the thigh full, and twist good. The fleece is very short and fine, weighing from $2\frac{1}{2}$ to 3 lb. The average weight of two-year old wethers is about 18 lb. per quarter, the mutton fine in the grain, and of an excellent flavour. These sheep have been brought to a high state of improvement by Mr Elman of Glynd, and other intelligent breeders. They prevail in Sussex, on very dry chalky downs, producing short fine herbage. See Plate XIII.

Norfolks.

In the *Norfolk* sheep the face is black, horns large and spiral; the carcase is very small, long, thin, and weak, with narrow chines, weighing from 16 to 20 lb. per quarter; and they have very long dark or grey legs, and large bones. The wool is short and fine, from $1\frac{3}{4}$ to 2 lb. per fleece.

This race have a voracious appetite, and a restless and unquiet disposition, which makes it difficult to keep them in any other than the largest sheep-walks or commons. They prevail most in Norfolk and Suffolk, and seem to have been retained solely for the purpose of folding; as it does not appear they have any other good property to recommend them, besides being good travellers, for which they seem well adapted, from their very long legs and light lean carcases.

Cheviots.

The *Cheviot* breed are without horns, the head bare and clean, with jaws of a good length, faces and legs white. (See Plate X.) The body is long, but the fore-quarters generally want depth in the breast, and breadth both there and on the chine; though, in these respects, great improvement has been made of late. They have fine, clean, small-boned legs, well covered with wool to the hough. The weight of their carcase, when fat, is from 12 to 18 lb. per quarter; their fleece, which is of a medium length and fineness, weighs about 3 lb. on an average.

Though these are the general characters of the pure Cheviot breed, many have grey or dun spots on their faces and legs, especially on the borders of their native district, where they have intermixed with their black-faced neighbours. On the lower hills, at the extremity of the Cheviot range, they have been frequently crossed with the Leicesters, of which several flocks, originally Cheviot, have now a good deal both of the form and fleece.

The best kind of these sheep are certainly a very good mountain stock, where the pasture is mostly green sward, or contains a large portion of that kind of herbage, which is the case of all the hills around Cheviot, where those sheep are bred. Large flocks of them have been sent to the Highlands of Scotland, where they have succeeded so well as to encourage the establishment of new colonies; yet they are by no means so hardy as the heath or black-faced kind, which they have in many instances supplanted.

Heath Breed.

Of those races of sheep that range over the mountainous districts of Britain, the most numerous, and the one probably best adapted to such situations, is the *heath* breed, distinguished by its large spiral horns, black faces and legs, fierce wild-looking eyes, and short firm carcases covered with long open coarse shagged wool. Their weight is from 10 to 16 lb. a quarter, and they carry from 3 to 4 lb. of wool each. They are seldom fed until they are three, four, or five years old, when they fatten well, and give excellent mutton, and highly-flavoured gravy. Different varieties of these sheep are to be found in all the western counties of England and Scotland, from Yorkshire northwards, and they want nothing but a finer fleece to render them the most valuable upland sheep in Britain. See Plate XII.

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Herdwicks.

The *Herdwick* sheep are peculiar to that rocky mountainous district, at the head of the Duddon and Esk rivers, in the county of Cumberland. They are without horns, have speckled faces and legs, wool short, weighing from 2 to $2\frac{1}{2}$ lb. per sheep, which, though coarser than that of any of the other short woolled breeds, is yet much finer than the wool of the heath sheep. The mountains upon which the Herdwicks are bred, and also the stock itself, have, time immemorial, been farmed out to herds, and from this circumstance their name is derived.

Dun-faced.

The *Dun-faced* breed, said to have been imported into Scotland from Denmark or Norway at a very early period, still exists in most of the counties to the north of the Firth of Forth, though only in very small flocks. Of this ancient race there are now several varieties, produced by peculiarities of situation, and different modes of management, and by occasional intermixture with other breeds. We may, therefore, distinguish the sheep of the mainland of Scotland from those of the Hebrides, and of the northern islands of Orkney and Zetland.

Hebrides.

"The Hebridean sheep is the smallest animal of its kind. It is of a thin lank shape, and has usually straight short horns. The face and legs are white, the tail very short, and the wool of various colours, sometimes of a bluish grey, brown or deep russet, and sometimes all these colours meet in the fleece of one animal. Where the pasture and management are favourable, the wool is very fine, resembling in softness that of Shetland; but, in other parts of the same islands, the wool is stunted and coarse, the animal sickly and puny, and frequently carries four, or even six horns."

"The average weight of this poor breed, even when fat, is only 5 or $5\frac{1}{2}$ lb. per quarter, or nearly about 20 lb. per sheep. It is often much less, only amounting to 15 or 16 lb.; and the price of the animal's carcase, skin and all, is from 10s. to 14s. We have seen fat wedders sold in the Long Island at 7s. a-head, and ewes at 5s. or 6s. The quantity of wool which the fleece yields is equally contemptible with the weight of the carcase. It rarely exceeds one pound weight, and is often short of even half that quantity. The quality of the wool is different on different parts of the body; and inattention to separating the fine from the coarse, renders the cloth made in the Hebrides very unequal and precarious in its texture. The average value of a fleece of this aboriginal Hebridean breed is from 8d. to 1s. Sterling. From this account, it is plain that the breed in question has every chance of being speedily extirpated." (Macdonald's *Report of the Hebrides*, p. 447.)

Zetland.

In the Zetland Isles, it would appear that there are two varieties; one of which is considered to be the native race, and carries very fine wool; but the number of these is much diminished, and in some places they have been entirely supplanted by foreign breeds. The other variety carries coarse wool above, and soft fine wool below. "They have three different successions of wool yearly, two of which resemble long hair more than wool, and are termed by the common people *fors* and *scudda*. When the wool begins to loosen in the roots, which generally happens about the month of February, the hairs or *scudda* spring up; and when the wool is carefully plucked off, the tough hairs continue fast, until the new wool grows up about a quarter of an inch in length, then they gradually wear off; and when the new fleece has acquired about two months' growth, the rough hairs, termed *fors*, spring up, and keep root, until the proper season for pulling it arrives, when it is plucked off along with the wool, and separated from it, at dressing the fleece, by an operation called *forsing*. The *scudda* remains upon the skin of the animal, as if it were a thick coat, a fence against the inclemency of the seasons, which provident nature has furnished for supplying the want of the fleece.

"The wool is of various colours. The silver grey is thought to be the finest; but the black, the white, the *mourat* or brown, is very little inferior; though the pure white is certainly the most valuable for all the finer purposes in which combing wool can be used." *

Mainland.

In the northern part of Kincardineshire, as well as in most other of the northern counties, there is still a remnant of this ancient race, distinguished by the yellow colour of the face and legs, and by the dishevelled texture of the fleece, which consists in part of coarse, and in part of remarkably fine wool. Their average weight in that county is from 7 to 9 lb. a quarter, and the mutton is remarkably delicate and highly flavoured. (*Kincardineshire Report*, p. 385.)

Merinos.

The last variety we shall mention is the Spanish or *Merino* breed, bearing the finest wool of the sheep species. The males usually have horns of a middle size, but the females are frequently without horns; the faces and legs are white, the legs rather long, but the bones fine. The average weight per quarter of a tolerably fat ram is about 17 lb., and that of ewes about 11 lb. The shape of this race is far from being perfect, according to the ideas of English breeders, with whom symmetry of proportion constitutes a principal criterion of excellence. The *throatiness*, or pendulous skin beneath the throat, which is usually accompanied with a sinking or hollow in the neck, presents a most offensive appearance, though it is much esteemed in Spain, as denoting both a tendency to fine wool and a heavy fleece. Yet the Spanish sheep are level on the back and behind the shoulders; and Lord Somerville has proved, that there is no reason to conclude, that deformity in shape is in any degree necessary to the production of fine wool.

Fleece.

The fleece of the Merino sheep weighs upon an average, from 3 to 5 lb. In colour it is unlike that of any English breed. There is on the surface of

* Sir John Sinclair *on the Different Breeds of Sheep, &c.*—Appendix, No. 4. (Account of the Shetland Sheep by Thomas Johnston, p. 79.)

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the best Spanish fleeces, a dark brown tinge, approaching almost to a black, which is formed by dust adhering to the greasy properties of its pile; and the contrast between this tinge and the rich white colour below, as well as that rosy hue of the skin which denotes high proof, at first sight excites much surprise. The harder the fleece is, the more it resists any external pressure of the hand, the more close and fine will be the wool. Here and there indeed a fine pile may be found in an open fleece, though this occurs but rarely. Nothing however has tended to render the Merino sheep more unsightly to the English eye, than the large tuft of wool which covers the head; it is of a very inferior quality, and classes with what is produced on the hind legs; on which account, it does not sort with any of the three qualities, viz. *Rafinos* or prime, *Finos* or second best, and *Tercenos*, the inferior sort, and consequently is never exported from Spain.

Travelling flocks.

The Spanish flocks which yield fine wool, are sometimes distinguished by the appellation of *Trashumante*, on account of their travelling from one end of the kingdom to the other, though there are flocks that never travel, with wool equally fine. They are wintered in Estremadura, and other warm provinces in the south; and during the summer months, they graze on the northern mountains of Castile, Leon and Asturias; but we shall have occasion to see, before concluding this section, that this change of place is by no means necessary to the fineness of their wool: in Britain, at least, the quality of the wool has been preserved, and even improved, without any such peculiarity of management.

Merinos were first brought into England in 1788, but did not excite much interest before His Majesty's sales, which began in 1804. The desirable object of spreading them widely over the country, and subjecting them to the experiments of the most eminent professional breeders, has been greatly promoted by the institution of the Merino Society, in 1811, which now comprehends some of the greatest landholders, and the most eminent breeders in the kingdom. See Plate XIV.

### 2. *Breeding and Rearing.*

Great perfection to which the breeding of sheep has been carried in England.

A greater degree of perfection has been attained in the breeding of sheep, than in any other species of live stock; and in this branch, in particular, the breeders of England stand higher than those of any other country. In the body of the work, under the Article Sheep, some account has been given of the means by which Mr Bakewell raised his stock, to a state of excellence in regard to fattening at an early age, with a moderate consumption of food, and with the smallest proportion of offal, which has been with difficulty equalled, certainly has not been exceeded by the most skilful of his successors.

We have therefore purposely deferred the observations, which it seems necessary to offer on the different systems of breeding, to this part of our article; though they may apply generally to other species of animals as well as to sheep.

Modes of Breeding.

The males and females possessed of the properties the breeder wishes to acquire, may be, 1. of the same family; 2. of the same race, but of different families; or, 3. of different races.

In-and-in.

The first method is called *breeding in-and-in*. This requires that animals of the nearest relationship should be put together, and was long supposed to produce a tender diminutive and unhealthy progeny. It is probable, that many objected to it from its appearing unnatural and incestuous. This prejudice opposed a very great obstruction to improvement; for if a male and female, out of the same dam, or got by the same sire, were never to be put together however excellent they might be, a stock that should by any means have become better than others, could not be long preserved from deterioration by strangers, nor could it be still farther improved by selection. Mr Bakewell had the merit of removing this prejudice in some degree; and by breeding in the same family for a great many years, succeeded in raising his sheep to a degree of perfection, which no other fattening animal ever attained in any age or country.

"It is certainly," says Mr Culley, one of the most eminent of his disciples, "from the *best males and females*, that the *best breeds* can be obtained or preserved."—"When you can no longer find *better males* than your own, then by all means breed from them, whether horses, neat cattle, sheep, &c. for the same rule holds good through every species of domestic animals; but upon no account attempt to breed or cross from worse than your own; for that would be acting in contradiction to common sense, experience, and that well established rule, "*That best only can beget best*," or, which is a particular case of a more general rule, viz. "*That like begets like*." (Culley *on Live Stock*, p. 11.)

This reasoning is opposed by others, who however rather deny the premises, than dispute the conclusion. It has been contended, that there never "did exist an animal without some defect in constitution, in form, or in some other essential quality;" that "this defect, however small it may be at first, will increase in every succeeding generation, and at last predominate to such a degree, as to render the breed of little value."—"Mr Bakewell very properly considered a propensity to get fat as the first quality in an animal, destined to be the food of man. His successors have carried his principle too far; their stock are become small in size, and tender, produce little wool, and are bad breeders. (Sebright *on improving the Breeds of Domestic Animals*, p. 11, 14.)

It is admitted, however, that *breeding in-and-in* will have the same effect in strengthening the good as the bad properties, and may be beneficial if not carried too far, particularly in fixing any variety that may be thought valuable. And, again, the same writer observes, "There may be families so nearly perfect, as to go through several generations without sustaining much injury from having been bred *in-and-in*; but a good judge would, upon examination, point out by what they must ultimately fail, as a mechanic could discover the weakest part of a machine before it gave way. (Sebright *on improving the Breeds of Domestic Animals*, p. 12.)

In reply to this, it may be said, that as excellencies as well as defects must be communicated, both of them, without any particular selection, would be

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found in the same degree, and bearing the same proportion to each other, in the descendants, as in the ancestors. If any one principle of selection be invariably adopted, it is no doubt true, that size might at last be sacrificed to a propensity to fatten, but then, a remedy might easily be applied, before any serious injury had been sustained, by merely reversing the principle of selection. So that this objection rather applies to the skill of the breeder, than to the measure itself.

"But one of the most conclusive arguments, that crossing with a different stock is not necessary to secure size, hardiness, &c. is the breed of wild cattle in Chillingham park, in the county of Northumberland. It is well known these cattle have been confined in this park for several hundred years, without any intermixture, and are perhaps the *purest breed* of cattle of any in the kingdom. From their situation and uncontrolled state, they must indisputably have bred from the nearest affinities in every possible degree; yet we find these cattle exceedingly hardy, healthy, and well formed, and their size, as well as colour, and many other particulars and peculiarities, the same as they were five hundred years since." (Culley *on Live-Stock*, p. 10.)

Crossing families of the same Race.

Notwithstanding all this, it must be admitted, that there is a great diversity of opinion among intelligent men respecting the expediency of this mode of breeding, and in most instances, perhaps, a pretty strong prejudice against it. The most common practice therefore is, to breed from different families of the same race. When these have been for sometime established in a variety of situations, and have had some slight shades of difference impressed upon them, by the influence of different soils and treatment, it is found advantageous to interchange the males, for the purpose of strengthening the excellencies, or remedying the defects of each family. Of this advantage, Mr Bakewell could not avail himself; but it has been very generally attended to by his successors. Mr Culley, for many years, continued to hire his rams from Mr Bakewell, at the very time that other breeders were paying a liberal price for the use of his own; and the very same practice is followed by the most skilful breeders at present. In large concerns, two or more *streams* of *blood* may be kept distinct for several generations, and occasionally intermixed with the happiest effects by a judicious breeder, without having recourse to other flocks.

Crossing different Breeds.

The only other method is, by crossing two distinct breeds or races, one of which possesses the properties which it is wished to acquire, or is free from the defects which it is desirable to remove. This measure can only be recommended, when neither of the former methods will answer the purpose. The very distinction of breeds implies a considerable difference among animals in several respects; and although the desirable property be obtained, it may be accompanied by such others as are by no means advantageous to a race, destined to occupy a situation which had excluded that property from one of its parents. To cross any mountain breed with Leicester rams, for example, with a view to obtain a propensity to fatten at an early age, would be attended with an enlargement of size, which the mountain pasture could not support; and the progeny would be a mongrel race, not suited to the pastures of either of the parent breeds. If the object be to obtain an enlargement of size, as well as a propensity to fatten, as is the case when Cheviot ewes are crossed with Leicester rams, the progeny will not prosper on the hilly pastures of their dams, and will be equally unprofitable on the better pastures of their sires. But the offspring of this cross succeeds well on those intermediate situations on the skirts of the Cheviot hills, where though the summer pasture is not rich, there is a portion of low land for producing clover and turnips.

General Rules.

In every case where the enlargement of the carcase is the object, the cross breed must be better fed than its smaller parent. The size of the parents should also be but little disproportioned at first; and when some increase has been produced, one or more crosses afterwards may raise the breed to the required size. With these precautions, there is little reason to fear disappointment, provided both parents are well formed. (*General Report of Scotland*, Vol. III. p. 14—18).

Breeding of Males.

The breeding of males, still more in this species than in cattle, has long been a separate pursuit; and there are few flocks skilfully managed, in which it is not still the practice to have recourse occasionally to rams, hired at a high price from those men whose chief attention is devoted to this branch of business.

Letting.

These rams are shown for hire, at certain times and places during the summer, where every one may select such as promise to maintain or improve the particular state of his flock, and at such prices as his means and experience may justify. Two or more individuals frequently join together in the hire of one ram, to which they put the best of their ewes, for the purpose of obtaining superior males for the future service of the rest of their flocks; and in particular cases, when the owner of the ram does not choose to part with him, even for a season, ewes are sent to him to be covered at a certain price *per* head; superior animals of this class being very seldom sold altogether. Much as this mode of doing business has been reprobated as a monopoly, and much as there may sometimes be of deception in *making up* rams for these shows, all intelligent practical men must agree, that there can be no better method of remunerating eminent breeders, and of spreading their improvements most widely, in the shortest period, and at the least possible expence. A single ram thus communicates its valuable properties to a number of flocks, often in distant parts of the country, without distracting the attention of ordinary breeders from their other pursuits. It is a striking instance of the division of labour, which in this, as in other branches, has been productive of the most beneficial results to all concerned, and to the community at large.

Season of breeding.

Rams and ewes are allowed to copulate earlier or later, according to the prospect of food for their young at the period of parturition,—usually in October and the early part of November; and as the time of gestation with sheep is twenty-one weeks, the lambs are accordingly dropped in March or April. The management of the Leicester breed, equally applicable to all the varieties kept on low arable land,

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having been detailed at some length in the articles already referred to, (see SHEEP in particular); we shall here give a condensed view of the best practices in regard to the stocks of hilly or mountainous districts; chiefly collected from the skilful management of the breeders of the Cheviot sheep on the borders of South and North Britain.

Management of Hill Sheep.

Copulation.

1. In November the rams are put to the ewes, a little earlier or later, according to the prospect of spring food, but seldom before the 8th or 10th of that month. The number of rams required is more or less, according to the extent of the pasture, and their own age and condition. If the ewes are not spread over an extensive tract, one ram to sixty ewes is generally sufficient. It is usually thought advisable to separate the gimmers (sheep once shorn) from the older ewes, and to send the rams to the latter eight or ten days before they are admitted to the former. Notwithstanding this precaution, which retards their lambing season till the spring is farther advanced, ewes which bring their first lamb when two years old, the common period on the best hill farms, are often very bad nurses, and in a late spring lose a great many of their lambs, unless they are put into good condition with turnip before lambing, and get early grass afterwards. This separation, and difference in the time of admitting the rams to the ewes and gimmers, should therefore be always attended to.

Selection of Males and Females.

2. When a farm under this description of stock, has the convenience of a few good inclosures, still more minute attention is paid by skilful managers. It is not sufficient that the rams are carefully selected from perhaps double the number, the ewes also are drawn out and assorted, and such a ram appropriated to each lot, as possesses the properties in form or fleece in which the ewes are deficient. In other cases, the best ram and the best lot of ewes are put together. When neither of these arrangements can be adopted, owing to the want of inclosures, it is the practice to send the best rams to the ewes for a few days at first, and those of an inferior description afterwards. In every case, when the farmer employs rams of his own flock, he is careful to have a few of his best ewes covered by a well-formed and fine-woolled ram, for the purpose of obtaining a number of good ram-lambs, for preserving or improving the character of his stock.

Separate Classes of a Flock.

3. The stock through winter, in a mere breeding farm, consists of ewes and gimmers which should have lambs in spring; ewe-lambs or hogs; and a few young and old rams. All these are sometimes allowed to pasture promiscuously, but on the farms around Cheviot, the ewes and ewe-hogs are kept separate, and the ewe-hogs are either put on rough pastures, which have been lightly stocked in the latter end of summer, or get a few turnips once a-day, in addition to the remains of their summer pasture. The most effectual preventive of the desolating distempers to which sheep of this age are liable, is turnips; and though they should never taste them afterwards, a small quantity is frequently given them during their first winter. After the rams have been separated from the ewes, they are usually indulged with the same feeding as the hogs.

4. The ewes, during winter, are seldom allowed any other food than what their summer pasture affords, except that a small part of it may sometimes be but lightly eaten, and reserved as a resource against severe storms. When these occur, however, as they often do in the Cheviot district, there is little dependence on any other food than hay. When the snow is so deep as completely to cover the herbage, about two stones *avoirdupois* of hay are allowed to a score of sheep daily, and it is laid down morning and evening in small parcels on any sheltered spot near the houses, or under the shelter of *stells* or clumps of trees, on different parts of the farm.

Hay.

5. In March, the ewes, at least the gimmers or young ewes, are commonly allowed a few turnips once a-day, on farms on which there is any extent of arable land; which are either carted to their pastures, or eaten on the ground, by bringing the sheep to the turnip field through the night. A part of the field, in the latter case, is cut off by nets or by hurdles, which inclose the sheep, in the same way as if they were intended for fattening. When they are ready to drop their lambs, they are no longer kept on the turnip field, and get what turnips may be left, on their pastures. But it is seldom that the turnips last so long, though it is desirable to have a few remaining to be given to the weakest ewes, or to such as have twins, in a separate inclosure.

Udder-Locking.

6. A few days before the time of lambing, the ewes are collected for the purpose of being *udder-locked*. The sheep are raised upon their buttocks, their backs next to the operator, who then bends forward and plucks off the *locks* of wool growing on or near the udders, for the purpose of giving free access to the expected lambs. At the same time he ascertains the condition of the ewes, and marks such as do not appear to be in lamb, which may then be separated from the others. This operation is not without danger, and several premature births are usually the consequence. It is therefore not so general a practice as it was formerly, though still a common one on many, if not on most farms.

7. On those farms, where the hogs have been allowed to pasture promiscuously with the ewes, which is seldom permitted on the Cheviot-hills, a separation should always take place at the commencement of the lambing season, and the lowest and finest part of the pasture ought to be exclusively appropriated to the nursing ewes.

Lambing.

8. The ewes begin to drop their lambs in the first or second week of April, according to the time at which the rams were admitted; and such as have twins generally lamb among the first of the flock. At this season, the most constant attention is indispensable on the part of the shepherds, both to the ewes in labour and to the newly dropped lambs. Though the Cheviot ewes are not so liable to losses in parturition, as some larger breeds which are in higher condition, and though they make good nurses, unless they are very lean and their food scanty, yet, among a large flock, there are always a number that need assistance in lambing, and in a late spring not a few who have not milk sufficient for their lambs, particularly among the gimmers or young ewes. A careful shepherd at this time always carries a bottle of milk along with him, which he drops from his own

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mouth into that of the lamb that may need it,—brings the ewes that have little milk to a better pasture, or to turnips,—and confines such as have forsaken their lambs in a small pen, or *barrack* as it is called, temporarily erected in some part of the farm-steading. The same confinement is necessary when it is wished to make a ewe that has lost her own lamb, nurse that of another ewe that has had twins, or that has perished in lambing, or is from any other cause incapable of rearing her lamb. The ewe, after being shut up for a few hours with the stranger lamb, usually admits it to the teat, and ever after treats it as her own; though sometimes a little deception is necessary, such as covering the stranger with the skin of her own lamb. At this important season, an inclosure of rich early grass, near the shepherd's cottage, is of vast advantage. Thither he carries the ewes and twins, —such as have little milk,—those that have been induced to adopt another's offspring,—and generally, all that need to be frequently inspected, and are in want of better treatment than the rest of the flock.

Castration.

9. As soon as the weather is favourable, after a considerable number of the ewes have lambed, they are collected into a fold, and all the male lambs are castrated, except a few of the best, reserved for rams. The ewe lambs are never spayed. It is advisable to perform this severe but necessary operation, when the lambs are but a few days old, if the weather will permit, instead of delaying till the end of the lambing season, as is still the case in some instances.

Late Lambs.

10. Towards the end of the lambing season, the ewes that have not yet dropped lambs, are separated from the flock, and kept by themselves, that they may be more under the eye of the shepherd, than if scattered over all the pasture. It is desirable to allow them finer grass for a few weeks after lambing, that their lambs may come to be nearly equal to the rest of the flock when weaned; or, if they are too late for this, that they may get ready for the butcher by the month of August, beyond which period the ewes must be much injured by suckling them.

Washing.

11. When the wool has risen sufficiently (and the proper time is easily known by the appearance of a new growth), the barren sheep are brought to the washing-pool. Sometimes they are hand-washed by men who stand in the pool, and have the sheep forced towards them singly; but more commonly, the Cheviot sheep, especially if the flock be numerous, are compelled to leap into the pool in a body for three or four times successively; and it is desirable that they should have room to swim a little, and come out on a green low bank on the opposite side. After being washed, the sheep are preserved as far as possible from rubbing against earthen dikes or banks, and from lying down on any dirty spot which might soil their wool.

Shearing.

There are two methods of shearing; in the one the operator sits on the floor or on the ground, lays the sheep on its back between his knees, begins with the belly, and afterwards, having tied the animal's legs, proceeds very expeditiously, at the rate of four or five sheep in the hour, or from forty to fifty a-day. This is the common method of shearing Cheviot-sheep. In the other, which is a much more perfect method, the shearer raises the animal on its buttocks, and, beginning at the neck, clips in a circular direction from the belly to the back-bone, for sometime with one hand and then on the opposite side with the other. The fleeces are neatly lapped up, after any filthy spots have been cut off, the shorn side outwards, beginning at the breech-wool and using that of the neck and shoulders as a bandage. Before the shorn sheep are turned out to pasture, they are marked, commonly with the owner's initials, by a stamp, or *boost* in provincial language, dipped in tar heated to a thin fluid state, and it is not unusual to place this mark on different parts of the body, according to the sheep's age.

Weaning Lambs.

12. The principal markets for Cheviot lambs in the south of Scotland, are held in the month of July, the first on the fifth of July; so that the lambs may commonly be weaned when about three months old, and sometimes sooner. When the ewes are gathered to be washed or shorn, the ewe lambs to be kept for supplying the place of the old ewes annually sold, are stamped in the same way as the ewes. The store-lambs are sent to some clean grassy pasture for a few weeks; and where the farm does not afford this accommodation, they must be *summered*, as it is called, at a distance. Several farms near Cheviot, and on the Lammermuir hills in Berwickshire, are appropriated to this purpose, the owner of the lambs paying so much a-head for six or eight weeks. In the mean time, the ewe hogs, or gimmers, as they are denominated after shearing, have joined the ewe stock, and the lambs, when brought home, go to the pasture which they had occupied. Wherever they may be kept in winter, it is always desirable to allow them a few turnips, along with a full bite of coarse herbage.

Milking Ewes.

13. When the lambs had been separated from the ewes, it was formerly the practice to milk the ewes for six or eight weeks or more, and this most objectionable management is still continued by several farmers. The most skilful store-masters, however, have either laid aside milking, unless for a few days, or have shortened the period to two or three weeks. The value of the milk for eight weeks, will not exceed from one shilling to one shilling and sixpence a-head, and the sheep are injured to at least three times that amount, independent of accidents at the milking fold. The cream is separated from the ewe milk, and made into butter for smearing, and the milk itself mixed with cow milk, and converted into cheese.

Drafting out old Ewes.

14. The next object of attention, is the drafting of the old ewes, to be sold in September or October. Their age, on the lower hills, is usually four years and a half, or they are disposed of after having reared three years lambs. In some situations they are kept on till a year older; but when they are purchased, as they usually are, to be kept another year on lower grounds, it is commonly for the interest of the store farmer, to sell them when still in their full vigour. Skilful managers do not content themselves with drafting them merely according to age; and as there is no disadvantage in keeping a few of the best another year, they take this opportunity of getting rid of such of the flock of other ages as are not of good shapes, or are otherwise ob-

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jectionable. As soon as the ewes to be disposed of are drawn from the flock, they are kept by themselves on better pasture, if the circumstances of the farm will admit of it. Sometimes they are carried on till they are fattened, and turnips are often purchased for them at a distance. When this is the case, it is not thought advisable to keep them longer, than till between Christmas and Candlemas, as an old ewe does not improve like a wether in the spring months.

Salving.

15. The last operation of the season is salving or smearing, which is usually performed towards the end of October or beginning of November, before the rams are sent to the ewes. The most common materials are butter and tar, mixed in different proportions; a greater proportion of tar being employed for the hogs or young sheep than for the older ones. The proportions are also different on almost every farm, and more tar is thought to be necessary, according to their greater elevation and exposure. In Roxburghshire, some mix two gallons of tar with thirty-six pounds of butter, as a sufficient allowance for threescore of sheep; but for the same number it is more common to allot only one stone (twenty-four pounds) of butter, to two gallons of tar. (*Roxburghshire Report*, p. 155.) A common proportion of late has been about fourteen pounds of butter, to two Scotch pints of tar (nearly 3½ quarts English wine measure) for ewes, and eleven pounds to the same quantity of tar for hogs. This mixture should smear from twenty to twenty-five of each, which is the number one man can do in a day. The expence, according to present prices, will be about nine pence for each sheep. Other articles, such as oil, palm-grease, tallow, &c. have been recommended in place of butter; but none of them are in general use, and the only addition that is approved of is a little butter milk. The butter is slowly melted and poured upon the tar, and the mixture is constantly stirred till it becomes cool enough for use. The wool is accurately parted into rows from the head to the tail of the animal, and the salve is carefully spread upon the skin with the point of the finger at the bottom of each row. The object of this operation is to destroy vermin, to prevent cutaneous diseases, and to promote the warmth and comfort of the animal during the storms of the ensuing winter. It is not necessary with sheep kept on low grounds, and well fed during winter, and it may be occasionally omitted for one season, particularly with old sheep, without material injury; but notwithstanding the ridicule that speculative writers have attempted to throw upon the practice, it is almost universally considered necessary and beneficial on high exposed situations, by the store farmers of the border hills. Smeared wool does not sell so high as white wool, but the greater weight of the former more than compensates for the difference in price. (*General Report of Scotland*, Vol. III.)

Besides those general rules of management which are applicable, with slight modifications, to all the numerous breeds of sheep, there are practices more or less extensively followed in particular districts, or with particular breeds; the most important of which are *cotting* and *folding*. In describing the Herefordshire sheep, the practice of keeping them in cots through the night has been already noticed, and a similar one is followed in some parts of the Highlands of Scotland, with the small dun faced flocks of that district.

Folding.

*Folding* is adopted, as a regular part of the system of management, in several counties of England, for the purpose of turning the dung of the animals to the best account for promoting the fertility of their arable land. The same thing has been done to a small extent in Scotland, but it forms no part of general management there; and is confined to those situations where, from the want of inclosures, it is necessary to the protection of the crops; and to small patches of what is still in the ancient state of *outfield*, as a preparation for corn.

Folding breeds.

The sheep best adapted to the fold, are those of the more active, short-woolled varieties, such as the Norfolk, Wiltshire, and South Down breeds; the heavy long woolled kinds being less hardy, and some of them, as the Leicesters, much too valuable for a mode of treatment that converts them into dung carriers. The following calculation will show, that though, in open lands, the practice may be in some cases tolerated on the ground of conveniency or expediency, it can possess no recommendation as a profitable mode of management in other circumstances. And the best farmers, indeed, from Bakewell, who used to say that it was robbing Peter to pay Paul, down to the present time, agree in reprobating sheep-folding as a branch of general management.

"This morning (September 22d 1780) measured a sheep-fold, set out for six hundred sheep, consisting of ewes, wedders, and grown lambs. It measures 8 by 5½ rods, which is somewhat more than seven rods to one hundred, or two yards to a sheep."

"August 29, 1781. Last autumn made an accurate experiment, on a large scale, with different manures for wheat, on a sandy loam, summer-fallowed.

"Part of an eighteen acre piece was manured with fifteen or sixteen loads of tolerably good farm-yard dung an acre; part with three chaldrons of lime an acre; the rest folded upon with sheep twice; the first time at the rate of six hundred sheep to a quarter of an acre, (as in first Minute), the second time thinner.

"In winter and spring, the dung kept the lead; and now, at harvest, it has produced the greatest burden of straw.

"The sheep-fold kept a steady pace from seed-time to harvest, and is now evidently the best corned, and the cleanest crop.

"The lime, in winter and spring, made a poor appearance, but after some showers in summer, it flourished much, and is now a tolerable crop, not less, I apprehend, than three quarters an acre.

"From these data, the value of a sheep-fold, *in this case*, may be calculated.

"It appears from the first Minute, that one hundred sheep manured seven square rods daily. But the second folding was thinner; suppose nine rods, this is, on a par of the two foldings, eight rods a-day each folding.

"The dung could not be worth less than half a crown a load; and the carriage and spreading ten

Sheep.

shillings an acre; together, fifty shillings an acre; which quantity of land the hundred sheep teathed twice over in forty days.

Value of manure.

"Supposing them to be folded the year round, they would, at this rate, fold nine acres annually; which, at fifty shillings an acre, is twenty-two pounds ten shillings a hundred, or four shillings and sixpence a-head.

"In some parts of the island, the same quantity of dung would be worth five pounds an acre, which would raise the value of the teathe to nine shillings a-head; which, at two pence a-head a-week, is more than the whole year's keep of the sheep.

"It does not follow, however, that all lands would have received equal benefit with the piece in consideration; which, perhaps, had not been folded upon for many years, perhaps never before; and sheep-fold, like other manures, may become less efficacious the longer it is used on a given piece of land." (Marshall's *Rural Economy of Norfolk*, Vol. II. p. 29.)

It must readily occur, that to fold on land in tillage all the year is nearly impracticable; and that where it could be done, the manure would be greatly diminished in value from rain and snow, to say nothing of the injury to the sheep themselves. So that the estimate of four shillings and sixpence, or nine shillings a-head, is evidently in the extreme

Objections to Folding.

According to the experience of Mr Arthur Young (*Farmer's Kalendar*), the same land will maintain one fourth more stock when the animals are allowed to depasture at liberty, than when confined during the night in folds. The injury to the stock themselves, though it is not easy to mention its precise amount with any degree of accuracy, cannot well be doubted, at least in the case of the larger and less active breeds, when it is considered that they are driven twice a-day sometimes for a distance of two, or even three miles, and that their hours of feeding and rest are in a great measure controlled by the shepherd and his boy. "When they are kept in numerous parcels, it is not only driving to and from the fold that affects them, but they are in fact driving about in a sort of march all day long, when the strongest have too great an advantage, and the flock divides into the head and tail of it, by which means one part of them must trample the food to be eaten by another. All this points the very reverse of their remaining perfectly quiet in small parcels." Another writer observes, "that were the pasture sheep of Lincolnshire to be got into a fold once a-week, and only caught one by one, and put out again immediately, it would prevent their becoming fat." (Parkinson *on Live Stock*, Vol. I. p. 367.) The only sort of folding ever adopted to any extent by the best breeders is on turnips, clovers, tares, and other rich food, where the sheep feed at their ease, and manure the land at the same time.

Another mode of management somewhat akin to this practice, and which is similar to one that has been warmly recommended in a recent publication (Sir J. Sinclair's *Husbandry of Scotland*), as if it had been formerly unknown, is described and commented on by Mr Young as follows: "This practice is, to confine them at night in a sheep-yard, well and regularly littered with straw, stubble, and fern; by which means you keep your flock warm and healthy in bad seasons, and at the same time raise a surprising quantity of dung,—so great a quantity, if you have plenty of litter, that the profit will be better than folding on the land. A great improvement in this method would be, giving the sheep all their food (except their pasture,) in such yard; viz. hay and turnips, for which purpose they may be brought up not only at night, but also at noon, to be baited; but if their pasture be at a distance, they should then, instead of baiting at noon, come to the yard earlier in the evening, and go out later in the morning. This is a practice that cannot be too much recommended; for so warm a lodging is a great matter to young lambs, and will tend much to forward their growth: the sheep will also be kept in good health; and, what is a point of consequence to all farms, the quantity of dung raised will be very great. If this method is pursued through the months of December, January, February, March, and April, with plenty of litter, one hundred sheep will make a dunghill of at least sixty loads of excellent stuff, which will amply manure two acres of land; whereas one hundred sheep folded (supposing the grass dry enough) will not in that time equally manure an acre."

Sheep. Sheep-yards.

That such a method may be advantageous in particular cases, it would be rash to deny; but, generally, it is not advisable, either on account of the sheep, or any alleged advantage from the manure they make. As to the sheep, this driving and confinement, especially in summer, would be just as hurtful as folding them in the common way; and it has been found, that their wool was much injured by the broken litter mixing with the fleece, in a manner not to be easily separated: besides, now that it is the great object of every skilful breeder to accelerate the maturity of his sheep, as well as other live stock,—among other means, by leaving them to feed at their ease, and, if circumstances permit, in small parcels,—such a practice as this can never be admissible in their management. And with regard to manure, there can be no difficulty in converting into it any quantity of straw, stubble, and fern, by cattle fed in fold-yards, on green herbage in summer, and turnips, or other succulent food, in winter; while the soil, especially if it be of a light porous quality, is greatly benefited, both by the dung and treading of sheep allowed to consume the remainder of both sorts of food on the ground. It is true, that the dung of sheep has been generally supposed to be more valuable than that of cattle; but accurate experiments have not been made to determine the difference in this respect among these and other polygastric animals. The greater improvement of pastures by sheep is probably owing as much to their mode of feeding, as to the richer quality of their dung.

Improvement of Wool by crossing with the Merinos.

On the subject of breeding and rearing sheep, it would be inexcusable to omit noticing the great advantages likely to result to the nation from the judicious and successful experiments of Lord Somerville, Dr Parry, and others, in crossing our native breeds with the Merino race; and should the same

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sagacity and perseverance, that have been hitherto almost exclusively employed on the *form* of the animal, be hereafter directed to the improvement of the *fleece* of our short-woolled sheep, there is reason to hope that we shall soon become altogether independent of foreign supplies for this material of the staple manufacture of England.

Dr Parry's Experiments.

The land on which Dr Parry began his experiments was high, of a thin staple, dry, unsheltered, and, consequently, unproductive; and, as his other avocations did not permit him constantly to superintend its management, he became impressed with the belief, that its most profitable application would be to a breed of sheep, the return of which should chiefly depend on the fleece; and such a breed he proposed to obtain by means of crossing with the Merinos, some of which had then (1792,) been recently imported by the King. Accordingly he fixed, as the basis of his experiments, on the Ryeland breed, which has long been reputed as affording some of the finest wool in the island.

Time of Lambing.

Dr Parry's lambs have been yeaned at different periods, though he seems to prefer the latter end of December, and throughout the whole of January, as the most desirable season in his situation; but as the Merino and Merino-Ryeland breeds come into the world extremely bare of wool, it is indispensably requisite that every night the flock should be well sheltered; the ewes sometime before and during lambing, and both ewes and lambs afterwards, as long as the severe weather continues. In April 1806, not one of his ewes had died in lambing; and out of two hundred lambs he had then lost only five, of which two were from two-toothed ewes, and one was produced dead.

Winter Food.

The ewes and lambs are fed in winter with lintseed made into a thick jelly, ground oil-cake, sometimes grains, cabbages, rape, rouen or after-grass saved through winter, winter and spring vetches, and hay. They have never got peas, corn, or bran; and the Doctor has had little experience of turnips, which, on his farm, he finds much inferior to cabbages—his chief dependence during that season.

"My manner," says he, "of feeding and treating my ewes and lambs, during the winter and spring, will best appear from that which I now practise with regard to seventy-four ewes, and as many lambs. Early in the morning they have 56 lb. of hay in cribs, in a grass field adjoining to the farm-yard. At half-past four in the afternoon, $3\frac{1}{2}$ cwt. of cabbages, cut in pieces, are given them, strewed on the grass in the same field. As soon as it grows dark, they are driven under the sheds, where 28 lb. of hay is allotted to them in cribs; and five nights in the week they have in the house $10\frac{1}{2}$ quarts of lintseed made into jelly, with seven times as much water; sometimes alone, at other times mixed with a little chaff of hay in troughs. The two other nights they have, instead of the jelly, six gallons of ground oil-cake, mixed with chaff in the same manner. What remains of the cabbages at night is eaten up clean in the course of the following morning.

Salt.

"Salt I never gave to my flock but once, and that in the following way: A small field of lattermath, cut in September, had been so often wetted, that I despaired of its ever being eaten. While it was putting into the rick, I strewed some salt between the layers; the consequence was, that cows and sheep greedily devoured it, scarcely leaving a single blade." (*Communications to the Board of Agriculture*, Vol. V. p. 505.)

Lavatories.

Dr Parry objects to washing the wool on the sheep's back before shearing. The fleece is so thick, that, when thoroughly soaked with water, it is very long in drying; and if the weather prove wet and cold, the sheep are evidently much incommoded. He therefore recommends public lavatories, as in Spain, for cleansing the wool after being shorn. His sheep are shorn about the second week of June; and if the weather be then unfavourable, he thinks it would be fit to house them for two or three nights or days after the operation.

Housing.

Shearing Lambs.

The lambs have been always shorn unwashed at the end of July, or beginning of August, without appearing to have suffered any injury. The fleece of such lambs as are rather coarse, he thinks, should be always shorn, as he has shown that the wool of many of this race is comparatively coarse, even in those individuals in which the fleeces afterwards acquire the finest quality. The finer fleeced lambs may be left unshorn, as it has been proved, that no loss is sustained by delaying shearing them till the usual period.

Effects of Crossing,

The effects of successive crosses, both on the form and the fleece of the progeny, are ably illustrated by this accurate experimentalist. With regard to the former, Dr Parry candidly declares, that his only object, the improvement of the fleece, did not allow him to give attention to the best forms in selecting his breeders; but, notwithstanding this, "my sheep," he observes, "are in general shorter in the legs and necks, have smaller bones, a rounder barrel, a wider loin, and consequently a better hind-quarter than any pure Merinos I have happened to see, except one particular ram belonging to Lord Somerville." This change he attributes to the female or Ryeland blood, which, in forming the progeny, acts most on the carcase, while that of the male or Merino chiefly affects the skin and fleece.

On the Carcase,

and on the Fleece.

The statements of Dr Parry as to the improvement of the fleece, apparently just in theory, have been confirmed by the trials made with his wool by respectable manufacturers, and the opinions of competent judges regarding the fineness of the fabrics which have been made from it. As it was his great object to cover the Merino-Ryelands with as fine a fleece as the Spanish wool of commerce, he did not accurately register the observations he had made on the quality of the early crosses; but he found that "the first mixture of the Merino with the Ryeland adds about one-third, or somewhat less, to the fleece of the latter breed, without appearing to have much influenced the fineness of the filament. In after-crosses, some curious circumstances occur. It is well known that the wool of the Merino and the Ryeland are both short, and the latter the shortest; neither of them usually exceeding, in the ewes, $2\frac{1}{2}$ inches in length. But the second or third mixture of these breeds carries the wool of the ewe to the length of four, and sometimes six inches, with great increase of weight,

but still considerable coarseness in the filament. The fourth cross brings the wool to the Spanish standard, in point of fineness, and greatly reduces the length, leaving it still somewhat greater than that of the pure Merino. In every stage of the experiment, the wool is profitable, either in quality or weight."

According to the general opinion of cultivators on the Continent, any breed of ewes, however coarse and long in the fleece, will, on the fourth cross of the Merino ram, give progeny with short wool equal to the Spanish. Of the truth of this proposition, however, Dr Parry justly expresses some doubts, derived from his own experience and that of others. But it is certain, he adds, that one cross more will, in most cases, effect the desired purpose.

Successive Crosses.

"If we suppose the result of the admixture of the blood of the Merino ram to be always in an exact arithmetical proportion, and state the native blood in the ewe as 64, then the first cross would give $\frac{32}{64}$ of the Merino; the second $\frac{48}{64}$; the third $\frac{56}{64}$; the fourth $\frac{60}{64}$; the fifth $\frac{62}{64}$; the sixth $\frac{63}{64}$; and so on. In other words, the first cross would leave 32 parts in 64, or half of the English quality; the second 16 parts, or one-fourth; the third 8 parts, or one-eighth; the fourth 4 parts, or one-sixteenth; the fifth 2 parts, or one-thirty-second; the sixth 1 part, or one-sixty-fourth; and so on.

"Now, if the filament of the Wiltshire, or any other coarse wool, be in diameter double that of the Ryeland, it is obvious, that, according to the above statement, it would require exactly one cross more to bring the hybrid wool of the former to the same fineness as that of the latter. This, I believe, very exactly corresponds with the fact. The difference between one-eighth and one-sixteenth is very considerable, and must certainly be easily perceived, both by a good microscope, and in the cloth which is manufactured from such wool. In the latter method, it certainly has been perceived; but I have hitherto had no opportunity of trying the difference by the former. The fifth cross, as I have before observed, brings the Merino-Wilts wool to the same standard as the fourth of the Merino-Ryeland." (*Communications to the Board of Agriculture*, Vol. V. p. 438.)

The success which has attended this gentleman's well conducted experiments, will best appear from the following statement of the wool produce of his farm, at the shearing at midsummer 1806, furnished by him to the Board of Agriculture, and published in the fifth volume of their Communications; in the Supplement to the Essay, from which we have chiefly collected the foregoing particulars:

ool produce of Dr arry's rm.

"The whole land in my occupation during the preceding year, was one hundred and sixty-five acres, of which twenty were under the plough; and I bought for my sheep a ton and a half of oil-cake, twelve bushels of lintseed, and a few bushels of grains. On the other hand, with the addition of two quarters of oats, and half as many beans, I entirely supported on the same ground three farm-horses for one year, and a fourth for half a year. I also furnished the entire hay for four coach-horses, besides the food of a useful jack-ass, and the summer-keep for two cows. Under these circumstances, the produce of the wool was as follows:

| | lb. | oz. | lb. | oz. |
|---|---|---|---|---|
| Unwashed wool from my improved breed | | | 1596 | 3½ |
| Washed wool of 7 half-Dorsets, 27 lb. 8 oz. which, if of my breed, would have been, unwashed, | 31 | 8 | | |
| Washed wool from 20 Leicester South Downs, 77 lb. which, from my breed unwashed, would have made | 90 | 0 | 391 | 8 |
| Washed wool from 60 Leicester Ryelands, 200 lb. 8 oz., which from my breed unwashed, would have been | 270 | 0 | | |
| Unwashed wool from 195 lambs, yielding, if shorn, more than 1¼ lb. each | | | 243 | 12 |
| Total | | | 2231 | 7½ |

Now, if we suppose the consumption by the other animals which I have specified, taken in connection with the extraneous food of the sheep, to equal the produce of fifteen acres, the sheep land will be reduced to one hundred and fifty, and the return of the wool *per* acre, will be 14 lb. 14 oz., which at only 3s. *per* lb. in the yolk throughout the fleece, will give L. 2, 4s. 7½d. *per* acre, on land certainly not worth, on an average, twenty-six shillings.

"I am myself fully persuaded that, in the former part of this Essay, I have greatly under-rated the average weight of the fleeces of my flock, if they had been, as they are now likely to be, for a sufficient number of generations well fed. Ten rams of different ages from four teeth upwards, purchased of me by Mr Birkbeck, yielded last year 97 lb. or nearly 9¾ lb. each, of wool in the yolk; and, of these, two gave 11 lb. 15 oz. each, and one, which had the finest fleece, 12 lb. This weight, which I believe considerably exceeds that of any pure Merino fleece ever produced in England, and which fully equals in clean wool that of the boasted fleeces of France, was, doubtless, owing to due care and good keep. My own crops last year failed, and the arable land which I hold, is not, in my estimation, half enough to afford proper winter sustenance for my sheep. This year, however, my flock promises to yield a larger clip of wool than last season."

Several other distinguished individuals, have taken a lead in improving the fleeces of our native short-woolled breeds, by crossing them with the Merinos, and, while their patriotic exertions deserve well of their country, have considerably increased their own profits. At the head of these perhaps, we ought to place Lord Somerville, who undertook a voyage to Portugal for the sole purpose of selecting from the best Spanish flocks, such sheep as united in the greatest degree the merit of a good carcase to a superior fleece. Notwithstanding the difficulties he had to encounter, augmented by the war between Great Britain and Spain, he brought home, in 1801, a flock of the first quality, selected from the *Trashumanté* or travelling breeds of Merinos, which was the admiration of the Spanish shepherds, through whose flocks they passed in their journey to England. Small flocks of Merinos are now established in Ireland and Scotland; and Mr Malcolm Laing has been very

Lord Somerville's flock.

Sheep.

successful with a numerous one, so far north as the Orkney Isles.

Merino and South Downs.

We shall conclude our account of this valuable race and its cross breeds, with an extract from a letter, sent by Mr Birkbeck, a professional farmer of the highest class, to Dr Parry, and quoted by the Doctor in the essay above referred to. "The fleeces of the first cross, (between Merinos and South Downs), washed, are to the parent South Downs as six to five in weight, and as three to two in value *per* pound. Thus,

100 South Down fleeces, $2\frac{1}{2}$ lb. each at 2s. L. 25.
100 First cross ——— 3 lb. ——— 3s. L. 45.

"So much for wool; and were it not for the air of extravagance it might give my statement, I should add, that there is an evident improvement, as to usefulness of form and disposition to fatten, in a large proportion of individuals. I had the courage to exhibit at Lord Somerville's shew, in March last, five ewe-hogs from your rams, and the honour to bear away the prize from all competitors, by the merit of carcase and fleece jointly. On the whole, I believe that the improvement of the wool may go on, without detriment to the carcase, until we shall attain a breed of sheep with Spanish fleeces, and English constitutions; but I am also convinced, that this must be the result of careful and judicious selection."

### 3. *Fatting.*

Age of fatting.

After what has been said in the chapter on arable land, (See TURNIPS, page 135), and in the second chapter, (See PASTURES, page 154), little remains to be added on this point. The age at which sheep are fatted depends upon the breed, some breeds, such as the Leicester, maturing at an earlier age than others, under the same circumstances; and also on the abundance and quality of the food on which they are reared, a disposition to early obesity, as well as a gradual tendency towards that form which indicates a propensity to fatten, being materially promoted by rich food, while the young animals are yet in a growing state. On good land, the Leicester wethers are very generally brought to a profitable state of fatness, before they are eighteen months old, and are seldom kept on for fatting beyond the age of two years. The Highland breeds, on the other hand, though prepared by means of turnips, a year at least sooner than they could be in former times, usually go to the shambles when from three to four years old. The ewes of the first description are commonly fatted after having brought lambs for three seasons, that is, after they have completed their fourth year; and those of the small breeds, at from five to seven years of age, according to circumstances.

Food.

Besides the numerous flocks fatted on pastures for the supply of the market during summer, a very large proportion, especially of the sheep kept on arable land, is fatted chiefly on turnips, the winter and spring consumption of butcher-meat being now abundantly provided for by means of this root, in all those districts where the best courses of husbandry prevail. We have already mentioned the weight of the different breeds in the description of them—the mode of feeding, under the heads of *Pastures* and *Turnips*—and shall now only add, that it is an invariable rule with all good managers never to allow this, or any other animal reared solely for the shambles, ever to lose flesh, from its earliest age till it is sent to the butcher;—that it is found of much advantage, with a view to speedy fattening, as well as to the economy of food, to separate a flock into divisions corresponding with its different ages, and the purpose of the owner as to the time of carrying them to market;—and that the change from the food of store to fatting stock—from that which is barely capable of supporting the condition which they have already attained, to that which is adapted to their speedy improvement in fatting, ought to be gradual and progressive. Thus, very lean sheep are never, in good management, put to full turnips in winter, nor to rich pastures in summer; they are prepared for turnips on good grassland—often on the after-grass of mown grounds; and kept on second year's leys, and afterwards a moderate allowance of turnips, if they are to be fatted on pastures. It is a common practice, in the instance of the Leicesters, to keep all that are not meant for breeding always in a state of fatness, and, after full feeding on turnips through winter and spring to finish them on the first year's clovers early in summer, when the prices of meat are usually the highest.

Sheep. General Rules.

The luxury of the age has called forth the ingenuity of man to accelerate the course of nature, at an expence which, in this species in particular, is in no degree compensated by the intrinsic value of the young animal as human food. *House-lambs* are fed in such numbers as the demand may require, in the vicinity of London and other large towns, where they are sold in the early part of the season, commonly at much higher prices than fat sheep of full growth. The Dorsetshire breed, as we formerly observed, can be made to yean at almost any season of the year, and they are therefore the only kind kept near London. But in the neighbourhood of those towns where the rich are willing to dispense with lamb during the early part of winter, other breeds are made to furnish the supply at a more advanced period of the season.

House-Lambs.

London Practice in feeding them.

The following account of the London practice may be useful to those farmers who find it their interest to give their attention to this branch of management:

"The sucklers, salesmen, and butchers of London, are aware that such lambs as have *sharp barbs* on the inside of their lips, are certainly of a *deep colour* after being butchered; and all those whose *barbs* are naturally *blunt*, do as certainly *produce fair meat*.

"This knowledge has been the occasion of *many lambs of the latter kind being kept for rams, and sent into Dorsetshire, expressly for the purpose of improving the colour of the flesh of house-lambs.*

"*The issue of such rams can generally be warranted fair, and such meat always sells at a higher price;* hence arose the mistaken notion, that Middlesex rams were necessary to procure house-lambs.

"The sheep which begin to lamb about Michaelmas are kept in the close during the day, and in the house during the night, until they have produced twenty or thirty lambs. These lambs are then put

Sheep || Swine.

into a lamb-house, which is kept constantly well littered with clean wheat straw; and chalk, both in lump and in powder, is provided for them to lick, in order to prevent looseness, and thereby preserve the lambs in health. As a prevention against gnawing the boards, or eating each other's wool, a little wheat-straw is placed, with the ears downwards, in a rack within their reach, with which they amuse themselves, and of which they eat a small quantity. In this house they are kept, with great care and attention, until fit for the butcher.

"The mothers of the lambs are turned, every night at eight o'clock, into the lamb-house to their offspring. At six o'clock in the morning, these mothers are separated from their lambs, and turned into the pastures; and at eight o'clock, such ewes as have lost their own lambs, and those ewes whose lambs are sold, are brought in and held by the head till the lambs by turns suck them clean: they are then turned into the pasture; and at twelve o'clock, the mothers of the lambs are driven from the pasture into the lamb-house for an hour, in the course of which time each lamb is suckled by its mother. At four o'clock, all the ewes that have not lambs of their own are again brought to the lamb-house, and held for the lambs to suck; and at eight, the mothers of the lambs are brought to them for the night.

"This method of suckling is continued all the year. The breeders select such of the lambs as become fat enough, and of proper age, (about eight weeks old,) for slaughter, and send them to market during December, and three or four succeeding months, at prices which vary from one guinea to four, and the rest of the year at about two guineas each. This is severe work for the ewes, and some of them die under excess of exhaustion. However, care is taken that they have plenty of food; for when green food (viz. turnips, cole, rye, tares, clover, &c.) begins to fail, brewers' grains are given them in troughs, and second-crop hay in racks, as well to support the ewes, as to supply the lambs with plenty of *milk*; for, if *that* should not be abundant, the lambs would become stunted, in which case, no food could fatten them.

"A lamb-house, to suckle from one hundred and sixty to one hundred and eighty lambs at a time, should be seventy feet long, and eighteen feet broad, with three coops of different sizes at each end, so constructed as to divide the lambs according to their ages." (*Middlesex Report*, p. 355.)

## Sect. IV. Swine.

Swine a subordinate Species of Stock.

Though there are many instances of this species of live stock being kept in such numbers as to be a source of very considerable emolument to their owners, yet, generally speaking, swine are viewed by farmers merely as a subordinate concern, and, perhaps, in most cases, their chief value is held to consist in their being maintained on what would otherwise be entirely lost. With millers, brewers, distillers, and dairymen, they are an object of more importance, and return, for the offals they consume, a greater weight of meat (according to some double the weight) than could be obtained from cattle. In those parts where potatoes are raised as a fallow crop, much beyond the demand for them as human food, as is the case in particular in Ireland and the west of Scotland, the rearing and feeding of swine, the most of them sent to a distance in the state of bacon and pickled pork, is a branch of management on which great dependence is placed for the payment of their rents and other charges.

It has been made a question, whether swine will pay for being wholly fed on crops raised for this purpose; and various calculations have been offered, to show how much they will return for a given quantity of corn and roots (see principal article, *Index*); but the results are so discordant, that much more accurate experiments must be made before any thing certain can be stated on this point. Perhaps the principal consideration which affects the question is, the extremely prolific nature of the animal, which renders it easy, in a very short time, to supply them in too great numbers for the demand. It is this circumstance, probably, that has, more than any other, prevented the farmers of arable land from employing any large portion of their crops in feeding swine, the flesh of which varies in price more than that of other butcher meat, and often at very short intervals. Yet, if their food be herbage and roots, with a small allowance of corn or pulse in the last stage of fatting, and if the breeds are judiciously chosen, and well managed, there seems no reason to doubt that, in many situations, swine will yield as much, perhaps, on an average of years, a greater profit, for the food they consume, than any other species of live stock.

Great Differences in the Varieties of this Species.

It is only in particular districts that so much attention has been paid to this animal, as to give rise to any accurate distinction of breeds; and nowhere has it received any considerable portion of that care in breeding, which has been so advantageously employed on the other animals of which we have treated. Yet among none of the varieties of those is there so great a difference as among the breeds of this species, in regard to the meat they return for the consumption of a given quantity of food. Some races can with difficulty be made fat, even at an advanced age, though fed from the trough with abundance of such food as would fatten any other animal; while others contrive to raise a valuable carcase out of materials on which no other creature could subsist.

Breeds.

Mr Culley mentions only three breeds, viz. the Berkshire, the Chinese, and the Highland or Irish; but other writers have found a distinct breed in most of the counties of England, which they have thought proper to describe separately. The Chinese race has been subdivided into seven varieties or more; and it would be easy to point out twice the number of as prominent distinctions among the sorts in the third class. But such an affectation of accuracy is as useless as it would be tedious. One general form, approaching to that of other animals kept for their carcase, ought certainly to be preferred; and the size, which is the other distinguishing characteristic, must be chosen with a view to the food provided for their maintenance, and not because it is possible to raise the individuals to a great, and probably unprofitable weight. The fineness of bone, and the broad, though also deep, form of the chest, denote in this, as in the

Swine.

other species, a disposition to make fat with a moderate consumption of food; and, while it may be advisable to prefer the larger breeds in those places where bacon and flitches are in most demand, the smaller breeds are most esteemed for pickling, and are, beyond all doubt, most profitable to those farmers, who allow them little else than the range of the farm-yard, and the offals of the kitchen.

Berkshire.

The *Berkshire* pigs, now spread through almost every part of England, and several places of Scotland, are in general of a reddish colour, with black spots, large ears hanging over their eyes, short legged, small boned, and inclined to make fat. The surprising weight that some of these hogs have been fed to, would be altogether incredible, were not the facts well attested. "On Monday the 24th of January 1774, a pig (fed by Mr Joseph Lawton of Cheshire) was killed, which measured, from the nose to the end of the tail, three yards eight inches, and in height four feet five inches and a half. When alive, it weighed 12 cwt. 2 qrs. 10 lb.; when killed and dressed, it weighed 10 cwt. 3 qrs. 11 lb. or 86 stones 11 lb. avoirdupois." (Culley *on Live Stock*, p. 173.)

Hampshire.

The *Hampshire* breed of hogs is also very large, being longer in the body and neck, but not of so compact a form as the Berkshire: they are mostly white, and well disposed to fatten.

Sussex.

The *Sussex* pig is distinguished by being black and white, but not spotted, frequently black at both ends, and white in the middle. Their general size, when full grown, is about 18 or 20 stone.

Suffolk.

The *Suffolk* white pig stands high, is narrow on the back, with a broad forehead; the hair is short, with many bristles; weight 16 to 19 stone.

Cheshire.

The *Cheshire* breed is distinguished by their gigantic size: in colour they are black and white, blue and white, (not spotted, but in large patches of black or blue), and some all white. Their heads are large, with very long ears, remarkably long in the body, very narrow in proportion to their size, with large bones, long legs, and much loose skin.

Shropshire.

The *Shropshire* pig is also a large coarse animal, with much bone and hair, and many bristles; their colour mostly white, with black patches, some rather sandy. They are said to be much liked by the distillers.

Rudgewick.

The largest breed of the island is supposed to be kept about Rudgewick, on the borders of Sussex and Surrey. They feed to an extraordinary size, and weigh, at two years old, nearly double or triple the weight of most other sorts at that age. (*Middlesex Report.*)

Chinese.

The Chinese breed is of different colours, white, black, black and white in irregular patches, and of a sandy hue; and their size is no less varied, though all of them smaller than the breeds already mentioned. The larger sort, such as weigh 10 or 12 stones when about a year old, or rather perhaps a cross with some native breed, may be recommended as the most suitable kind for arable farms, when their maintenance is to be got chiefly in the fold-yards. The form of the Chinese pig is generally good, and their flesh excellent, but it is easily made too fat for delicate stomachs.

General Observations.

The most numerous in the lowland counties of Scotland were, and in many places still are, very unprofitable animals. They are of a white colour; have light, narrow carcases, with bristles standing up from nose to tail; long legs; and are very slow feeders, even at an advanced age. In the Highlands and Hebrides, the breed, supposed by Dr Walker to be the aboriginal, is of "the smallest size, neither white nor yellow, but of a uniform grey colour, and shaggy, with long hair and bristles; they graze on the hills like sheep; their sole food is herbage and roots, and on these they live the whole year round, without shelter, and without receiving any other sustenance. In autumn, when they are in the best order, their meat is excellent, and without any artificial feeding; but when driven to the low country, they fatten readily, and rise to a considerable bulk." (Walker's *Hebrides*, Vol. II. p. 17.)

Orkney.

In the Orkney Islands they are commonly of a dark red, or nearly black colour, and have long bristles, with a sort of coarse wool beneath them.

Management.

The mode of *breeding*, the *food*, and the general *management* of swine, are all of them so much dependent on local circumstances, and are so much varied in consequence, that it is neither possible, nor would it be of any utility, to describe the practice of different counties, or rather of almost every different individual.

The period of gestation with swine is sixteen weeks. The pigs are commonly weaned when six weeks old; soon after which the sow is again in season, so that two litters are usually farrowed within the year; sometimes, though very rarely, five litters in two years. There are two things of particular importance to be attended to in the breeding of swine: They should not be allowed to farrow in winter, as young pigs are exceedingly tender, and can with difficulty be preserved in very cold weather; nor at a time when food is scarce, as is generally the case upon corn-farms in summer, if the stock of them is large. The months of February and August have been recommended as the best periods for parturition. (Henderson *on Swine*, p. 27.) Twenty swine are estimated to bring at an average seven pigs and a half each for their first litter (*Ibid.* p. 17.); but the number varies much, and many young pigs are lost soon after their birth by the unkindness of their dam, and by casualties, to which they are more exposed than most other young animals.

A sow in pigs should be separated from the herd some time before she is expected to farrow, carefully watched, and littered with a small quantity of dry short straw. Too much straw is improper, both at the time of farrowing, and for a week or two afterwards, as the pigs are apt to nestle beneath it unperceived by the sow, and are thus in danger of being smothered when she lies down. A breeding sow should be well fed, particularly when nursing; and it is advantageous early to accustom the pigs to feed from a low trough, on milk, or other liquid food, mixed with meal or bran. Such of the pigs of both sexes, as are not to be kept for breeding, are usually castrated or spayed when about a month old, and the whole may be weaned at the end of six or seven weeks. They should then be fed regularly, three times a-day,

Swine.

with meal and water a little warmed, until they are able to shift for themselves among the rest of the stock.

Cottager's Pig.

The food allowed, whether to growing or fattening swine, depends on the circumstances of their owners. The cottager's pig must be contented with the scanty offals of his kitchen, and of his dairy, the produce generally of a single cow; towards the end of autumn, a few potatoes are added, for the purpose of preparing it for slaughter, and perhaps a little meal is mixed with boiled potatoes for a week or two before. Such pigs, however, often thrive amazingly, make themselves moderately fat, and form a most valuable addition to the winter stores of their owners. In the south-eastern counties of Scotland, the hinds or married ploughmen are commonly allowed to keep a pig each, which they feed in this manner, and from which their families derive much benefit at very little expence.

Corn-farmers'.

On many corn-farms, the chief, and, not unfrequently, the only dependence of swine is on the straw-yards. The sweepings of the barn-floor, corn left upon the straw, and oats found among the dung of horses, with a share of the turnips given to the cattle in winter, and of the clover in summer, afford ample subsistence to swine, in the proportion, perhaps, of one to every five or six acres under corn, clover, and turnips. The kitchen and dairy give some assistance to pigs newly weaned, and also to such as are soon to be slaughtered. A great many are killed when about a year old, that have never been fed at any expence that can be estimated. A few pigs, if of a good breed, will always be moderately fat at that age with the run of the straw-yards, and their flesh is of an excellent quality.

Feeding for Bacon.

When farmers find it profitable to keep large swine that cannot be fattened for bacon, as is the practice in some of the western counties, without a regular supply of food being served up to them, the method is, to rear swine chiefly on raw potatoes and Swedish turnips, and to fatten them on these roots, boiled or prepared by steam, with a mixture of oat, barley, or bean and peas meal. Their troughs should be often replenished with a small quantity of food at a time, and kept always clean; and their food changed occasionally, and seasoned with salt. "If proper care be taken," says a late writer, "a feeding pig should not consume more than six Winchester bushels of oats made into meal. It ought to be shelled before it is ground, the same as for family use, but need not be sifted." (Henderson's *Treatise on Swine*, p. 26.)

Swine, it is well known, are very apt to get into forbidden ground; upon tillage-farms they are seldom, for this reason, permitted to go at large, unless sometimes for a few weeks on the stubbles, or where the number is so large as to afford the expence of constant herding. In many cases they are almost always confined to the cattle-yard, or a fold-yard beside their styes. Another bad property in this animal is, the habit of digging into the soil; for which the most effectual preventive is, to cut the two strong tendons of their snout, by a slight incision with a sharp knife, about an inch and a half from the nose. This may be done with little pain, and no prejudice to the animal, when about two or three

Mode of preventing their digging.

months old. The common practice of restraining them by rings fixed in the snout, is painful and troublesome; they must be replaced as often as they give way, and that happens so frequently, that rings afford but little security against this nuisance.

Styes.

Styes, or swine-houses, are set down in different situations, according to the numbers kept, and the manner of feeding them. The cottager erects a little hut contiguous to his dwelling, and many small farmers also choose to lodge them near the kitchen. If swine are kept chiefly in the straw-yard, their houses are so situated as to give ready access by a door which opens into it. (See Plate VIII.) The gentleman-farmer erects a range of low buildings on that side of his farm-offices which is least exposed to view, and incloses and subdivides a small yard for their use. Where this branch of husbandry is carried on in all its parts, there must be separate houses for sows heavy with young, and such as are nursing, for pigs newly weaned, for rearing and for fattening stock. (*General Report of Scotland*, Vol. III. p. 217.)

Pickled Pork.

In the pickling and kitting of pork, a branch of business which is carried on to a considerable extent at many of our seaports, the carcase is cut in pieces, and packed in kits made for the purpose, containing from one to two cwt. Salt is dissolved in water till the mixture be strong enough to swim an egg; it is then boiled, and, when cold, poured upon the pork. When the end of the kit is fixed in, the article is ready for being sent to market.

A late writer has given particular directions for the curing of bacon, founded upon a long course of experience, which therefore deserve to be more generally known. We shall give them in his own words.

Directions for curing Bacon.

"After the carcase has hung all night, lay it upon a strong table, or bench, upon its back, cut off the head, close by the ears, and cut the hinder feet so far below the hough as will not disfigure the hams, and have plenty of room to hang them by. Then take a cleaving knife, and, if necessary, a hand-mallet, and divide the carcase up the middle of the back-bone, laying it in two equal halves. Then cut the ham from the side by the second joint of the back-bone, which will appear on dividing the carcase; then dress the ham, by paring a little off the flank or skinny part, so as to shape it with a half-round point, clearing off any top fat that may appear. The curer will next take off the sharp edge along the back-bone with his knife and mallet, and slice off the first rib next the shoulder, where he will perceive a bloody vein, which he must take out, for if it is left in, that part is apt to spoil. The corners must be squared off where the ham was cut out.

"In killing a number of swine, what sides you may have dressed the first day lay upon some flags or boards, piling them up across each other, and giving each flitch a powdering of saltpetre, and then covering it with salt. Proceed in the same manner with the hams, by themselves, and do not omit giving them a little saltpetre, as it opens the pores of the flesh to receive the salt, and, besides, gives the ham a pleasant flavour, and makes it more juicy.

"Let them lie in this state about a week, then

Swine.

turn those on the top undermost, giving them a fresh salting. After lying two or three weeks longer, they may be hung up to dry in some chimney, or smoke-house. Or, if the curer chooses, he may turn them over again, without giving them any more salt; in which state they may lie for a month or two without catching any harm, until he has convenience for drying them. I practised for many years the custom of carting my flitches and hams through the country to farm-houses, and used to hang them in their chimneys and other parts of the house to dry, some seasons to the amount of five hundred carcases. This plan I soon found was attended with a number of inconveniences, yet it is still common in Dumfries-shire.

Smoke-House.

"About twenty years ago, I contrived a small smoke-house, of a very simple construction. It is about twelve feet square, and the walls about seven feet high. One of these huts requires six joists across, one close to each wall, the other four laid asunder at proper distances. To receive five rows of flitches, they must be laid on the top of the wall. A piece of wood strong enough to bear the weight of one flitch of bacon, must be fixed across the belly end of the flitch by two strings, as the neck end must hang downwards. The piece of wood must be longer than the flitch is wide, so that each end may rest upon a beam. They may be put so near to each other, as not to touch. The width of it will hold 24 flitches in a row, and there will be five rows, which will contain 120 flitches. As many hams may be hung at the same time above the flitches, contrived in the best manner one can. The lower end of the flitches will be within $2\frac{1}{2}$ or 3 feet of the floor, which must be covered five or six inches thick with saw dust, which must be kindled at two different sides. It will burn, but not cause any flame to injure the bacon. The door must be kept close, and the hut must have a small hole in the roof; so that part of the smoke may ascend. That lot of bacon and hams will be ready to pack up in a hogshead, to send off in eight or ten days, or a little longer, if required, with very little loss of weight. After the bacon is salted, it may lie in the salt-house as described, until an order is received, then immediately hang it up to dry.

"I found the smoke-house to be a great saving, not only in the expence and trouble of employing men to cart and hang it through the country, but it did not lose nearly so much weight by this process.

"It may be remarked, that whatever is shipped for the London market, or any other, both bacon and hams, must be knocked hard, and packed into a sugar hogshead, or something similar, to hold about ten hundred weight. Bacon can only be cured from the middle of September, until the middle of April." (Henderson's *Treatise on Swine*, p. 39.)

### Sect. V. Miscellaneous Live Stock.

Under this title we would comprise Asses, Mules, Goats, Rabbits, Pigeons, Poultry, and Bees; all of which have been treated of in the body of the work. See the indexes to Mammalia and Ornithology, and Poultry, Pigeons, and Bees, under separate articles. See also Bee in this Supplement.

Miscellaneous Live Stock.

The value of these species, as agricultural Live-Stock, is comparatively inconsiderable in Britain, notwithstanding their importance in some other countries; and, in an economical view, some of them are undoubtedly wasteful and pernicious. *Asses* and *mules* are seldom or never employed in field labour, though it was the opinion of Mr Bakewell, and a few other eminent agriculturists, that there would be some advantage in propagating the ass on account of its hardiness, and the coarse food on which it may be maintained. Trials have been made to improve our present breeds, by crosses with males introduced from foreign parts, without having had the effect however of bringing them into use, either for the plough or the cart; and wherever the services of a small animal are required, we have horses of all sizes, from nine to eighteen hands high, which seem better adapted to every purpose than asses or mules. *Goats* are to be found only in small numbers, except in some parts of the Highlands, and are kept chiefly for the medicinal quality of their milk. *Pigeons* are justly considered as a nuisance, by every respectable writer on rural economy, and certainly by every farmer who is within the reach of their depredations.

Asses and Mules.

Goats.

Pigeons.

*Rabbits* are a kind of stock, about which some difference of opinion still exists among intelligent men, though there are perhaps very few situations, in which they can be considered as more profitable than any other mode of occupancy. It is not merely that they in general return less for their food than other stock, but that they are also very difficult to confine, and most destructive to the crops and fences in their vicinity. Their number, though still considerable, has accordingly decreased, and continues to decrease, with the progress of improvement; and unless their skins shall become of much greater value than at present, they can be an object of consideration, only on such tracts as must otherwise be left to the animals that are still in a state of nature. In the present state of our agriculture, however, if it be found advantageous to retain this species, it is proper that the best breeds and the best mode of management, as well as their value, should be known.

Rabbits.

A deep, sandy, poor soil is the most suitable for rabbits, though, under good management, as turnips must be provided for winter, there should be parts of it capable of bearing that and other crops; and the situation may be either on the sides of hills, or on a flat surface. Artificial burrows are made with an auger, to reconcile them to the ground, and to preserve them from vermin, until they have time to make their own burrows; and on level warrens, this implement may be usefully employed from time to time afterwards. Warrens are commonly fenced with a sod wall, capped with furze or black thorn, in all about six feet high, and should always be kept in complete repair. Besides the rabbits, a number of sheep are usually kept in these grounds during the summer.

Artificial Burrows.

The *silver haired* rabbit is now more esteemed than the *grey*, though the latter is so much hardier, that if a warren be stocked with both, there will in a few

Varieties.

Miscellaneous Live Stock.

years be nothing but greys. (*Lincolnshire Report*, p. 382.) The skin of the grey rabbit is *cut*, that is, the "wool" is pared off the pelt, as a material of hats, whereas that of the silver haired, which sells much higher, is dressed as fur, and goes, it is said, principally to the East Indies." (Marshall's *Yorkshire*, Vol. II. p. 965.)

Breeding.

One buck will serve one hundred does; the doe takes the buck the day she brings forth, and goes thirty one days with young, which she suckles for about twenty two days, for the first half of which they are blind. But when confined in warrens, rabbits seldom breed more than twice a year, and some of them only once; in particularly wet, cold seasons, few or none bring more than one litter. (Parkinson *on Live Stock*, Vol. II. p. 299). The skins are in their best state, from the middle of November till Christmas, during which period, all that are not to be kept for breeding are slaughtered. Silver skins have been sold of late, at from 15s. to 21s. a dozen.

Taking.

"The best manner of taking rabbits is, by folds, by means of nets and cords. The day before the rabbits are intended to be taken, the warrener, with his assistants, incloses many acres of ground, the bank generally making one end, and sometimes part of a side: the forepart of the fold is left entirely open. Rabbits form their colonies in some part all together, at a distance from their feeding ground, and nearly all leave their home or burrows at the time of feeding, when the warrener fixes his nets, by two men beginning at each end, who meet in the middle: thus, in fine dry weather, they can nearly take all that is wanted at once; but it is a general practice to fold at two separate times, from each colony. Within the fold are formed what are termed angles, in that part nearest to the burrows; as the rabbits, when they return, and find themselves checked in getting home, will beat about by the nets: these angles are, therefore, so contrived, as to afford them an opportunity of secreting themselves, and are made thus:—an irregular groove or channel is cut, about twelve or fourteen inches deep, and about twelve inches wide; the sods being set up one against another, over the groove, so as to form a ridge, like the roof of a house; these channels are made of equal lengths, both ends being left open, so that when the rabbits meet they are head to head. When the rabbits find themselves prevented from returning to their former homes, and the day-light appears, hearing the warrener and his dogs enter the fold, they quickly run into the angles, when the warrener puts a sod against the open ends, to prevent their return; the few straggling rabbits remaining in the fold are hunted by boys with dogs; but the warreners have recourse to that method as little as possible, the dogs being apt to tear the skin, and injure the carcase." (Parkinson *on Live Stock*, Vol. II. p. 299.)

Winter food.

"Turnips, clover, and sainfoin are the most proper kinds of winter food for rabbits, as also thrashed oats or barley, when corn is tolerably cheap, may be given them with great propriety; the two latter need only be allowed when the ground is covered with snow, and when it does not blow about so as to cover the corn when laid down; but in severe storms, turnips are the most proper food, as they can find them by their scent, and will scratch the snow off when covered. Three large cart loads of turnips a-day, will fodder one thousand or one thousand one hundred couples of rabbits, which are about a proper quantity to be left as breeding stock, on 500 acres of inclosed warren land. In heavy snows, a great deal of money must be expended in clearing the snow from the warren walls, in order to keep as much as possible the rabbits within their bounds." (*Lincolnshire Report*, p. 389.)

Expence and produce.

Among several calculations to show the expence and produce, Mr Arthur Young seems to consider the following as the most accurate; and as he is a decided enemy to this stock, there is no reason to suspect exaggeration.

"Mr Holdgate states the expence of 1700 acres under rabbits, the silver sort, thus:

"Labour, three regular warreners, with extra assistance at killing,

| | | | | |
|---|---|---|---|---|
| sistance at killing, . . . . . . . | L. | 85 | 0 | 0 |
| Fences . . . . . . . . . . . | | 42 | 10 | 0 |
| Winter Food . . . . . . . . . | | 42 | 10 | 0 |
| Nets, traps, &c. &c. . . . . . . | | 14 | 3 | 4 |
| Delivery . . . . . . . . . . . | | 21 | 5 | 0 |
| Rent is said to be 7s. an acre . . . | | 595 | 0 | 0 |
| | L. | 800 | 8 | 4 |
| The capital employed is that sum, with the addition of stock paid for; suppose this 3 couples an acre, at 2s. 4d. . . | | 595 | 0 | 0 |
| | L. | 1395 | 8 | 4 |
| Interest of that sum one year, 5 *per cent* | | 69 | 5 | 0 |
| | L. | 1464 | 13 | 4 |

*Annual Account.*

| | | | | |
|---|---|---|---|---|
| Expences as above . . . . . | L. | 800 | 8 | 4 |
| Interest . . . . . . . . | | 69 | 5 | 0 |
| | L. | 869 | 13 | 4 |

*Produce.*

| | | | | |
|---|---|---|---|---|
| 10,000 couples at 2s. 4d. . . . . | L. | 1166 | 13 | 4 |
| Expences . . . . . . . . . | | 869 | 13 | 4 |
| Profit | L. | 297 | 0 | 0 |

or L. 24 *per cent.* (the five *per cent.* included) on capital employed. This is very great, reckoned on the capital, but small reckoned by rent, as it amounts to only half a rent. But suppose the gross produce L. 1500, which I take to be nearer the fact, then the account would stand thus:

| | | | | |
|---|---|---|---|---|
| Produce . . . . . . . | L. | 1500 | 0 | 0 |
| Expences . . . . . . | | 869 | 0 | 0 |
| Profit . . . . . . . . | L. | 631 | 0 | 0 |

or L. 47 *per cent.* on the capital.

"Take it how you will, it explains the reason for so many of these nuisances remaining. The investment of a small capital yields an interest that nothing else will; and thus the occupier will be sure never to convert them to better uses." (*Id.* p. 391.)

Miscellaneous Live Stock.

Poultry.

Of *Poultry* the most difficult to rear, and the most voracious and unprofitable, is the *Turkey*. *Geese*, which live and even fatten on grass, are considered by some persons as the most valuable, and in many parts of England the number is considerable *Ducks* are not only comparatively harmless, but, from their feeding chiefly on pernicious insects, are probably deserving of more attention than has hitherto been paid to them. But *common fowls* are by far the most numerous, and everywhere add something not inconsiderable to the income of the inhabitants of the country, and to the stock of food for the consumption of the people at large. The trade in eggs alone, between the country and the towns, is a matter of some importance, as affording profitable employment to those who collect them, and to others who afterwards send them in large quantities to the principal towns.

Eggs.

According to the Statistical Account of Scotland, the people of Hawick, a small town in the county of Roxburgh, more than twenty years ago received L. 50 weekly through the year, for eggs collected in the neighbourhood, and sent to Berwick for the London market; and in 1796, it was calculated that the peasantry of Mid-Lothian drew L. 8000 a-year for poultry and eggs. But in the way these fowls are commonly managed by farmers, there is reason to doubt whether they pay for the food they consume, and the waste they are too often allowed to commit. The number kept by any individual is commonly so small, as to obtain little of that attention that is given to other domesticated animals, and their ravages are accordingly greater, and their returns smaller, than they would otherwise be. Yet in the warm cottages of country labourers, the common farm-yard hen makes a valuable return for the food she requires, which is frequently potatoes, boiled and mashed, with a little oat-meal porridge, a portion of the daily meal of its owner. A comfortable degree of warmth is so essential, that some gentlemen have had stoves placed under their roosts.

Expence and Produce of Common Fowls.

The results of an experiment made with 6 hens and a cock, in 1807 and 1808, were, that they ate half a peck of barley weekly with very little other food, and laid 764 eggs in 52 weeks, the greatest number in the months of May and August, and the smallest in November and December. The eggs were sold in the London market at 1½d. each, and the nett profit, besides eleven chickens, was L. 2, 12s. 2d. They were confined in a small yard, well sheltered and heated by the fires of the houses with which it was surrounded; and prevented from *sitting* by means of a feather, thrust through the nostrils for a few days, the pain of which is supposed to have induced the hen to move about till the inclination to sit had passed away. (*Parkinson on Live Stock*, Vol. II.)

## CHAP. IV.

## GENERAL OBSERVATIONS ON THE AGRICULTURE OF BRITAIN.

Superiority of British Agriculture.

The Husbandry of a great part of Britain, both in respect to the cultivation of the soil and the breeding and management of live stock, is confessedly superior to that of any other country in Europe; and the quantity and value of its products, considering the character of the climate, as well as the industry, wealth, and respectability of its husbandmen, are without any parallel, either in ancient or modern times.

General Observations.

We find from Columella, that, under the Romans, the produce of the greater part of Italy was less than four times the seed (*lib.* iii. *cap.* 3.); and this notwithstanding an unproductive fallow every second year, and apparently a much greater attention to minutiæ, than would be compatible with the more extensive concerns of the British Farmer. The average crops of Britain have been stated so high as nine times the seed; and certainly, wherever the management is tolerably correct, cannot be less than double the proportion assigned by Columella to the richer soil and more genial climate of Italy. Of the agriculture of France before the Revolution, a very full and accurate account has been furnished by Mr Arthur Young, from which it is sufficiently evident how much the general produce of that country, the best cultivated perhaps next to Britain, was inferior to that of even our middling lands; and the progress it has made since, has not, according to the latest and apparently exaggerated accounts, been marked by any very great improvement either in live stock or machinery, the two most distinguishing parts of British husbandry.

It is natural to ask—to what causes this superiority is owing?—And why it is confined to a part of our territory, instead of being extended, as our great demand of late for foreign corn would have led us to expect, to all soils that are capable of profitable improvement? On these two points we now propose to offer a few very general remarks; and we shall submit them to the reader without affecting that precision of arrangement which more ample details would have required.

Division of Landed Property.

Objections to very Large Estates;

1. The territory of Britain is not engrossed by a few individuals, as that of the northern countries of Europe, nor divided into such minute portions as that of some of the small states of the Continent. The vast tracts of country held by a Russian or Polish nobleman, and the diminutive possessions of the Swiss, and more lately of the French peasantry, are almost equally inconsistent with the more productive systems of rural economy. The former are too large for the superintendence of one individual, with a view to profitable cultivation; and the existence of such extensive properties implies the degradation and poverty of the great body of the people, and the absence of a middle class, possessed of disposable capital, or at least of opportunities for its investment in the soil.

and to a Minute Division of Landed Property.

The latter, on the other hand, afford no room for the employment of capital, nor of those inventions by which the charges of cultivation are diminished, and its products augmented. Such small landed properties return little more than the wages of the manual labour by which they must necessarily be cultivated. Their small surplus produce, which every bad season annihilates, cannot afford subsistence to those other classes, whose labours are necessary to national prosperity and individual comfort; and a part of the families of the cultivators themselves, having neither

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food nor employment at home, must either emigrate or perish. To a certain extent these consequences have been already experienced, both in Ireland and the Highlands of Scotland; for it would be idle to maintain, that a minute division of land in tenancy, does not produce all the unhappy effects which must result from the minute division of land in absolute property.

Of two countries, in one of which estates are in general too large for the personal superintendence of the proprietors, and, in the other, the land is parcelled out into shares, little more than sufficient for the subsistence of their owners, the condition of the great body of the people must be very much alike. In neither can there exist that middle class, from which all valuable improvements proceed, nor any of those inventions which multiply and augment the productive powers of human industry. Both of these states of property must appear decidedly hostile to national prosperity. when measured by this unerring test—the quantity of the products of the soil which remains after defraying the charges of obtaining them; for upon this net surplus depend all the enjoyments of mankind beyond the mere necessaries of life, as well as the means of repelling foreign aggression, and preserving internal tranquillity.

Effects of both in some respects the same.

The distribution of the landed property of Britain is equally distant from both these extremes. Though it is necessary, perhaps, to the political constitution of the country, that there should be a number of large estates, yet their extent is seldom so great as to produce any of the bad effects just mentioned, even within the bounds of a single county. Over the rural economy of the nation these large properties exert scarcely any influence at all, excepting such of them as are held by entail, which is certainly a mode of tenure greatly at variance with the full improvement of the soil. Many instances might be pointed out, of very extensive estates, fully as well cultivated, and yielding as large a surplus for the general consumption, as our agriculture, in its present state, obtains from any equal extent of similar land. It is true, that to increase the political influence of great proprietors, too many of these estates are possessed by tenants at will; but this grievance is not peculiar to estates of this class; the largest estates of Scotland being occupied on leases. This most serious obstacle to spirited cultivation, must therefore be ascribed to political causes, and not to the engrossing of landed property.

Britain cultivated by a Class of Professional Men.

2. Another arrangement, which may serve to account for the superiority of British agriculture, is somewhat akin to that division of labour, by which all the arts have been carried to so great a degree of perfection in this country. Few great proprietors, comparatively, cultivate their own lands beyond the demands of pleasure and convenience. The far greater part of Britain is cultivated by professional men, with their own capital, and for their own profit. The price which they must pay for their temporary rights in the soil, in the shape of rent, instead of checking their exertions, has a powerful tendency to promote every profitable improvement, to discourage dangerous speculation, and to restrain wasteful expenditure. And as it is clearly the interest of such men, still more than of proprietors themselves, to obtain the largest produce at the least possible expence, the intermediate portion of the produce,—that which is disposable for the general consumption,—is consequently as large as industry and economy, in the present state of our agriculture, can make it. It is true, almost to a proverb, that farming, upon an extensive scale, is never profitable to a great landholder; and, with a view to the interest of the nation, it ought to be discouraged, as both wasteful and unproductive. In some countries this mode of farming is a matter of necessity,—as in the north of Europe, where a class of free tenants does not exist;—in others, the business of cultivation must be carried on as a sort of partnership, or joint concern between the proprietor and tenant, as on the *metairies* of France. Fortunately, the general distribution of wealth has long since removed the necessity for either of these methods in Britain.

Principle of the Connection between Landlord and Tenant.

To give full effect to the professional system, it is necessary that the rights of the landlord and tenant, respectively, should be clearly defined, and well secured by law and the private contract of the parties. The general principle which should regulate the terms of this connection seems to be, that, while the farm ought to be restored to the owner at the expiration of the tenant's interest, at least without deterioration, the tenant should be encouraged to render it as productive as possible during his possession. In both of these views, a lease for a term of years is scarcely less necessary for the interest of the landlord than of the tenant; and so much is the public interested in this measure, that it has been proposed by intelligent men, to impose a penal tax on the rent of lands held by tenants at will.

Advantages of Leases to Landholders.

That the value of the property is enhanced by the security which such a lease confers on the tenant, will be put beyond all doubt, if the rents of two estates for half a century back are compared; the one occupied by tenants at will, and the other by tenants on leases for a moderate term, and where the soil and situation are nearly alike in every respect. If the comparison be made between two tracts, originally very different in point of value, the advantages of leases will be still more striking. While that which is held by tenants at will remains nearly stationary, the other is gradually, yet effectually, improved, under the security of leases, by the tenant's capital; and, in no long period, the latter takes the lead of the former, both in the amount of the revenue which it yields to the proprietor, and in the quantity of produce which it furnishes for the general consumption. The higher rents and greater produce of some parts of Scotland, than of many of the English counties, where the soil, climate, and markets are much more favourable, must be ascribed to the almost universal practice of holding on leases in the former country, in a much greater degree than to any of the causes which have been frequently assigned. Less than a century ago, what are now the best cultivated districts of Scotland were very far behind the greater part of England; and, indeed, had made very little progress from the time of the

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feudal system. It is not fifty years since the farmers of Scotland were in the practice of going to learn from their southern neighbours an art, which was then very imperfectly known in their own country. But in several parts of England there has been little or no improvement since, while the southern counties of Scotland have uniformly advanced; and at present exhibit, very generally, a happy contrast to their condition at the middle of last century.

to Farmers,

In respect to farmers themselves, it cannot be necessary to point out the advantages of leases. It may be true, that, under the security of the honour of an English landlord, tenants at will have been continued in possession from generation to generation, and acquired wealth which he has never, like the landholders of some other countries, attempted to wrest from them. But there are few individuals in any rank of life, who continue for a length of time to sacrifice their just claims on the altar of pure generosity. Something is almost always expected in return. A portion of revenue in this case is exchanged for power, and that power is displayed not only in the habitual degradation of the tenantry, but in the control over them, which the landlord never fails to exert at the election of members of Parliament, and on all other political emergencies. No prudent man will ever invest his fortune in the improvement of another person's property, unless, from the length of his lease, he has a reasonable prospect of being reimbursed with profit; and the servility which holding at will necessarily exacts, is altogether incompatible with that spirit of enterprize which belongs to an enlightened and independent mind.

and to the Public.

The people at large are evidently most deeply affected by every measure which has a tendency to fetter the productive powers of the soil, and, at the same time, to depress one of their largest and most valuable classes. It is clearly their interest, that corn and other provisions should be supplied in abundance; and the people of England may justly complain of the want of leases, as one of the principal causes which checks the improvement of their own territory.

Duration of Leases.

What ought to be the term of a lease, can only be determined by a reference to the circumstances of each particular case. Lands naturally rich, or such as have already been brought to a high degree of fertility, requiring no great investment of capital, and returning all or nearly all the necessary outlay within the year, may be advantageously held upon short leases—such perhaps as give time for two, or at most three, of the rotations or courses of crops to which the quality of the soil is best adapted. The practice of England in this respect is extremely various,—almost every term, from twenty years downwards, being found in different parts of it. In Scotland, by far the most common period is nineteen years, to which it was formerly the practice, in some places, to add the life of the tenant. In that country, even when it is thought expedient to agree for a much longer term, this is still expressed in periods of nineteen years,—a sort of mysterious cycle, which seems to be no less a favourite with the courts of law, than with landholders and farmers. Yet this term is somewhat inconvenient, as it can never correspond with any number of the recognized rotations of arable land.

Long leases disapproved of.

It has been maintained by several writers, that a lease for twenty years is not sufficient to reimburse a tenant for any considerable improvements, and landholders have often been urged to agree to a much longer term, which, it is alleged, would be not less for their own interest than for that of the tenant. This is a question which our limits do not permit us to discuss, but, after viewing it in different lights, assisted by the experience of long leases in different parts of Scotland, we cannot help expressing some doubts of their utility, even in so far only as regards the parties themselves; and we are decidedly of opinion, that a greater produce will be brought to market, from any given extent of land held on successive leases of twenty years, for half a century, than if held on one lease of that duration, whether the term be specified, or indefinite, as in the case of a lease for life. As a general mode of tenure, leases for lives seem to us particularly objectionable.

Lord Kames's Lease for indefinite period.

The great advantages of a lease are so well known in Scotland, that one of her best agricultural writers, himself a landed proprietor, has suggested a method of conferring on it the character of perpetuity, to such an extent as, he thinks, would give ample security to the tenant for every profitable improvement, without preventing the landlord from resuming possession upon equitable terms, at the expiration of every specified period. But the author of this plan (Lord Kames), in his ardent wishes for the advancement of agriculture, at that time in a very backward state in his native country, seems to have overlooked the difficulties that stood in the way of its adoption; and the great advance in the price of produce, and consequently in the rate of rents, since his Lordship wrote, have long since put an end to the discussion which his proposal excited. For a form of a lease on his plan, the reader may consult Bell's *Treatise on Leases;* and the objections to the plan itself are shortly stated in the supplement to the sixth edition of the *Gentleman Farmer*, recently published.

Long Leases, with a periodical Rise of Rent.

There have been instances of long leases granted, upon condition of receiving an advance of rent at the end of a certain number of years; but covenants of this kind, meant to apply to the circumstances of a distant period, cannot possibly be framed in such a manner as to do equal justice to both parties; and it ought not to be concealed, that, in every case of a very long lease, the chances are rather more unfavourable to the landholder than to the farmer. If the price of produce shall continue to rise as it has done, till very lately, for the last forty years, no improvements which a tenant can be expected to execute will compensate the landlord's loss; and if, on the other hand, prices shall decline, the capital of most tenants must be exhausted in a few years, and the lands will necessarily revert to the proprietor, as has been the case of late in many instances. Hence a landholder, in agreeing to a long lease, can hardly ever assure himself that the obligations on the part of the tenant will be fully discharged throughout its whole term, while the obligations he incurs himself may always be easily enforced. He runs the risk of

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great loss from a depreciation of money, but can look forward to very little benefit from a depreciation of produce, except for a few years at most. Of this advantage a generous man would seldom avail himself; and, indeed, in most instances, the advantage must be only imaginary, for it would be overbalanced by the deterioration of his property.

Corn-Rents.

Where the circumstances of a landholder, the state of his property, and the wealth and enterprizing character of the tenantry, are such as to render long leases, or leases for an indefinite period, expedient, the most equitable mode, in regard to rent, would be to make it rise and fall with the price of corn or other produce. A rent paid in corn is, indeed, liable to serious objections, and can seldom be advisable in a commercial country.

Objections to Corn-Rents.

It necessarily bears hardest on a tenant when he is least able to discharge it. In very bad seasons, his crop may be so scanty as scarcely to return seed and the expences of cultivation, and the share which he ought to receive himself, as the profits of his capital, as well as the quantity allotted to the landlord, may not exist at all. Though, in this case, if he pays a money-rent, his loss may be considerable, it may be twice or three times greater if the rent is to be paid in corn, or according to the high price of such seasons. In less favourable years, which often occur in the variable climate of Britain, a corn-rent would, in numerous instances, absorb nearly the whole free or disposable produce, as it is by no means uncommon to find the gross produce of even good land reduced from twenty to fifty *per cent.* below an average, in particular seasons. And it ought to be considered, in regard to the landlord himself, that his income would thus be doubled or trebled, at a time when all other classes were suffering from scarcity and consequent dearth; while, in times of plenty and cheapness, he might find it difficult to make his expences correspond with the great diminution of his receipts. It is of much importance to both parties, that the amount of the rent should vary as little as possible from any unforeseen causes, though tenants in general would be perhaps the most injured by such fluctuations.

Plan for converting a Corn-Rent into Money.

To obviate these and other objections to a corn-rent, and to do equal justice at all times to both landlord and tenant, a plan has been lately suggested for converting the corn into money, adopting for its price, not the price of the year for which the rent is payable, but the average price of a certain number of years. The rent, according to this plan, may be calculated every year, by omitting the first year of the series, and adding a new one; or, it may continue the same for a certain number of years, and then be fixed according to a new average. Let us suppose the lease to be for twenty-one years, the average agreed on being seven years, and the first year's rent, that is, the price of so many quarters of corn, will be calculated from the average price of the crop of that year, and of the six years preceding. If it be meant to take a new average for the second and every succeeding year's rent, all that is necessary is, to strike off the first of these seven years, adding the year for which the rent is payable, and so on during all the years of the lease. But this labour, slight as it is, may be dispensed with, by continuing the rent without variation for the first seven years of the lease, according to the average price of the seven years immediately preceding its commencement, and, at the end of this period, fixing a new rent, according to the average price of the seven years just expired, to continue for the next seven years. Thus, in the course of twenty-one years, the rent would be calculated only three times; and for whatever quantity of corn the parties had agreed, the money payments would be equal to the average price of fourteen years of the lease itself, and of the seven years preceding it; and the price of the last seven years of the old lease, would determine the rent during the first seven years of the new one.

The landlord and tenant, it has been thought, could not suffer either from bad seasons or any change in the value of the currency, should such a lease as this be extended to several periods of twenty-one years. The quantity of corn, to be taken as rent, is the only point that would require to be settled at the commencement of each of these periods; and though this would no doubt be greater or less, according to the state of the lands at the time, yet it may be expected, that, in the twenty-one years preceding, all the tenant's judicious expenditure had been fully replaced. Instead of the twofold difficulty in fixing a rent for a long lease, arising from uncertainty as to the quantity of produce, which must depend on the state of improvement, and still more perhaps from the variations in the price of that produce, the latter objection is entirely removed by this plan; and in all cases where land is already brought to a high degree of fertility, the question about the quantity of produce may likewise be dispensed with.

Considered as applicable to Leases of nineteen or twenty-one years.

Upon this plan we shall take leave to observe, that, if it be applied to leases of nineteen or twenty-one years, the inconvenience resulting from uncertainty as to the amount of rent, as well as other difficulties which must necessarily attend it, would be as great perhaps as any advantages which it holds out to either of the parties. If it be said that a rent, determined by a seven years average, could not suddenly nor materially alter, this is at once to admit the inutility of the contrivance. The first thing which must strike every practical man is, that corn is not the only produce of a farm, and in most parts of Britain, perhaps not the principal source from which rent is paid; and there is no authentic record of the prices of butcher meat, wool, cheese, butter, and other articles in every county to refer to, as there is of corn. This is not the place to inquire whether the price of corn regulates the price of all the other products of land, in a country whose statute books are full of duties, bounties, drawbacks, &c. to say nothing of its internal regulations; but it is sufficiently evident, that, if corn does possess this power, its price operates too slowly on that of other products, to serve as a just criterion for determining rent on a lease of this duration. Besides, in the progress of agriculture, new species or varieties of the *cerealia* themselves are established even in so short a period as twenty-one years, the price of which may be very different from that of the corn specified in the lease. What security for a full rent, for instance, would it give to a landlord, to make the rent payable according to the price of

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barley, when the tenant might find it more for his interest to cultivate some of the varieties of summer wheat lately brought from the Continent? Or, according to the price of a particular variety of oats, when, within a few years, we have seen all the old varieties superseded, throughout extensive districts, by the introduction of a new one, the potatoe-oat, which may not be more permanent than those that preceded it? There can be no impropriety, indeed, in adopting this plan, for ascertaining the rent of land kept always in tillage, but it would be idle to expect any important benefits from it, during such a lease as we have mentioned.

and to longer Leases.

With regard to much longer leases, this plan will no doubt diminish the evils which we think are inseparable from them, but it cannot possibly reach some of the most considerable. Its utmost effect is to secure to the landholder a rent, which shall in all time to come be an adequate rent, according to the state of the lands and the mode of cultivation known at the date of the lease. But it can make no provision that will apply to the enlargement of the gross produce from the future improvement of the lands themselves, or of the disposable produce from the invention of machinery and other plans for economizing labour. And the objections just stated, in reference to a lease of twenty-one years, evidently apply much more forcibly to one of two or three times that length. Old corn-rents therefore, though much higher at present than old money rents, are seldom or never so high as the rents that could now be paid on a lease of twenty-one years. But, independent of these considerations, which more immediately bear upon the interests of the parties themselves, one insuperable objection to all such leases is, that they partake too much of the nature of entails, and depart too far from that commercial character which is most favourable to the investment of capital, and consequently to the greatest increase of land produce.

Covenants of Lease.

A lease for a term of years is not, however, in all cases, a sufficient encouragement to spirited cultivation; its covenants in respect to the management of the lands may be injudicious; the tenant may be so strictly confined to a particular mode of culture, or a particular course of crops, as not to be able to avail himself of the beneficial discoveries which a progressive state of agriculture never fails to introduce. Or, on the other hand, though this is much more rare, the tenant may be left so entirely at liberty, that either the necessity of his circumstances during the currency of the lease, or his interest towards its expiration, may lead him to exhaust the soil, instead of rendering it more productive. When a lease therefore is either redundant or deficient in this respect—where it either permits the lands to be deteriorated or prevents their improvement,—the connection between landlord and tenant is formed upon other views, and regulated by some other principle, than the general one on which we think it should be founded.

Restrictive clauses.

Notwithstanding the high authority of Dr Smith, restrictive covenants are always necessary to the security of the landlord, and in some cases beneficial also to the tenant. Their expediency cannot well be questioned, in those parts of the country where an improved system of agriculture has made little progress. A landholder, assisted by the advice of experienced men in framing these covenants, cannot adopt any easier or less offensive plan for the improvement of his property, and the ultimate advantages of his tenantry. Even in the best cultivated districts, while farms continue to be let to the highest responsible offerers, a few restrictive covenants cannot be dispensed with. The supposed interest of the tenant is too feeble a security for correct management, even during the earlier part of a lease, and in the latter part of it, it is thought to be his interest, in most cases, to exhaust the soil as much as possible, not only for the sake of immediate profit, but frequently in order to deter competitors, and thus to obtain a renewal of his lease at a rent somewhat less than the lands would otherwise bring.

With tenants at will, and such as hold on short leases, restrictive covenants are more necessary than with tenants on leases of nineteen or twenty years; but, in many instances, they are too numerous and complicated, and sometimes even inconsistent with the best courses of modern husbandry. The great error lies, in prescribing rules by which a tenant is positively required to act—not in prohibiting such practices, and such crops, as experience has not sanctioned. The improved knowledge, and the liberality of the age, have now expunged the most objectionable of these covenants; and throughout whole counties, almost the only restriction in reference to the course of crops is, that the tenant shall not take two culmiferous crops, ripening their seeds, in close succession. This single stipulation, combined with the obligation to consume the straw upon the farm, and to apply to it all the manure made from its produce, is sufficient not only to protect the land from exhaustion, but to ensure, in a great measure, its regular cultivation; for half the farm at least must, in this case, be always under either fallow or green crops. The only other necessary covenant, when the soil is naturally too weak for carrying annual crops without intermission, is, that a certain portion of the land shall be always in grass, not to be cut for hay, but depastured. According to the extent of this will be the interval between the succession of corn crops on the same fields; if it is agreed that half the farm, for instance, shall always be under grass, there can be only two crops of corn from the same field in six years. In this case not more than two-sixths being in corn, one-sixth in green crops or fallow, and three-sixths in clovers or grasses, it becomes almost impossible to exhaust any soil at all fitted for tillage. There are few indeed that do not gradually become more fertile under this course of cropping. It is sufficiently evident, that other covenants are necessary in particular circumstances, such as permission to dispose of straw, hay, and other crops from which manure is made, when a quantity of manure equal to what they would have furnished, is got from other places; and a prohibition against converting rich old grazing lands or meadows into corn lands. In this place we speak only of general rules, such as are applicable to perhaps nine-tenths of all the arable land of Britain, and such as are actually observed in our best cultivated counties.

For the last four years of a lease, the same cove-

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nants are generally sufficient, only they require to be applied with more precision. Instead of taking for granted, that the proportion of the farm that cannot be under corn will be properly cultivated, from the tenant's regard to his own interest, it becomes necessary to take him bound to this effect in express terms; the object generally being to enable the tenant, upon a new lease, to carry on the cultivation of the lands, as if the former lease had not terminated. What these additional stipulations should be, must depend in part on the season of the year at which the new lease commences, and in part on the course of crops best adapted to the soil, and the particular circumstances of every farm.

3. Enlargement of Farms.

3. The enlargement of farms to such a size as admits of arrangements and machinery for saving labour is the natural consequence of the progress of agriculture, and the acquisition of capital by cultivators, and becomes, in its turn, the cause of further improvements. We have not room to examine here the various objections to large farms which were urged by Dr Price, Lord Kames, and most of the economical writers of the last century. Much stronger reasons, certainly, than any that have been hitherto advanced, must be required to justify the interference of the Legislature with the rights of the agricultural classes—with that of a landholder to draw the greatest revenue from his property, and with that of a farmer to extend his concerns as far as his capital and abilities will permit. Even though it should be conceded to Dr Price, that a given extent of land yields a greater produce in the hands of several small farmers than of one great farmer, it still remains to inquire, what part of that produce can be spared for the general consumption?—and whether the labour of these people might not be employed with more advantage than on such minute portions of land as yield, even in the best seasons, little more than food for their own subsistence? In Britain, of which the families employed in agriculture are to those of the whole population only as 1 to 2.84, and in which the proportion of lands cultivated, or that may be cultivated, is not four acres to every individual, the great object ought certainly to be, to increase the *disposable* produce of the country for the supply of the general population.

Objections to large Farms.

The grand objection to large farms, that they depopulate the country, is not supported by facts. The population of the country has not only greatly increased since the enlargement of farms, but, in the ten years from 1801 to 1811, this increase appears to have been only two *per cent.* less than that of the town population. The fact is, that the increase of the rural population has been in a greater ratio than that of the town population, in those counties, such as Northumberland, where very large farms abound; and where, indeed, as is usually the case, this state of things is combined with a spirited and productive system of agriculture. Even in Lancashire, the ratio of increase is only two *per cent.* in favour of the towns; but no one will ascribe this to the enlargement of farms. The truth seems to be, that, wherever agriculture has made the greatest progress, whatever may be the size of farms, the increase of employment has been attended with a corresponding increase of population; and that the ratio of increase has been kept down below that of towns, by no other causes than the stationary condition or slow progress of agriculture in some parts, and the superior allurements of manufactures and commerce in others.

It is farther to be remarked, that, throughout the whole of the arable districts of Scotland, the number of people is proportionally greater on large than on small farms. The number of hands required on the former is too great to be lodged in the farmer's own house; and, therefore, on all such farms cottages are built for their residence. These cottages are generally inhabited by married men, whose families find employment in hoeing green crops, and other easy work, from a very early age. In the less improved counties, on the other hand, where small farms still prevail, unmarried servants are preferred, as, on such farms, there is little or no employment for the families of married servants. Our limits do not permit us to inquire how far the poor laws of England operate against the employment of married servants, living in cottages on every farm; but the happy effects of this arrangement are manifest in the south-eastern counties of Scotland, as we shall notice immediately.

Married Farm-Servants.

Cottage-Farms.

The possession of land is held by some writers to be so important, with a view to the comforts of the labouring classes, as well as to the increase of the rural population, that they have not been contented with objecting to large farms, but have proceeded to recommend what are called *cottage-farms*, for country labourers generally. Of this plan we might say at once, that it must be limited everywhere by the demand for labour; and that, wherever such small allotments are required by the state of agriculture, they will gradually be formed from motives of interest, without the necessity of any higher control. They are at this time common in many parts of Britain; and a different system has been established in other parts, for no other reason than because of its superior advantages to all concerned. Yet, as cottage-farms bear a very plausible appearance in the eye of speculative men, it seems necessary to offer some farther remarks on a question which has been so often agitated.

If every labourer had a comfortable cottage, and four acres of land at a moderate rent, as recommended by some of the correspondents of the Board of Agriculture, there is reason to believe that his condition might be much improved for a few years, supposing the demand for labour to continue the same as at present. Even the colonies which this class would every year send forth in quest of new cottages might be supplied for a time; and though the wages of labour must sink very fast, still this premium might enable the labourers to multiply with little interruption for several generations. At last, however, the multiplication of cottage-farms must necessarily stop, and a great proportion of the people, without land and without the means of employment, would either sink into helpless misery, or be driven by despair to the commission of every species of enormity. Such was the state of England at the breaking up of the feudal system, the policy of which also was to increase the number of the people, without regard to

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the means of their employment; and such, though in a much less degree, is the present state of those parts of the united kingdom in which cottage-farms are the most prevalent.

The whole question, we think, is capable of being most satisfactorily decided, by an appeal to the plain mercantile criterion of rent. If a hundred labourers, each of them possessing four acres, can pay a higher rent than one farmer can pay for the whole four hundred, buildings, fences, and repairs, being estimated, we can see no reason why they should not be preferred; but if this be not the case, we are greatly at a loss to conceive with what justice landholders can be called upon to submit to sacrifices which no other class of the community is ever expected to make. We might, with just as much reason and justice, require a manufacturer to employ a certain number of hands in proportion to the amount of his capital, however unprofitable to him might be their labour.

Two Classes of Cottagers.

But, farther, in all our best agricultural counties, there are two sorts of cottages occupied by two distinct classes of labourers. Of the first sort are the small agricultural villages, where those mechanics and other labourers reside, who could not find full employment on any one farm. To such men small farms are advantageous, or otherwise, according to the nature and the constancy of their employment.

The other class of cottagers, to which we have already alluded, are ploughmen and other servants employed throughout the year on a particular farm. To these men small possessions of land are almost as unsuitable as they would be to a country gentleman's domestics. But a small garden is usually attached to each cottage; and they are also allowed to keep a cow, as part of their wages,—not upon any particular spot of their own, but along with their master's cows. Their fuel is carried home by their master's teams, and a part of his own field, ready dressed, is assigned them for raising potatoes, flax, or other crops for their families. Thus, with little risk from the seasons or markets, and without any other demand on their time than a few leisure hours will satisfy, these people enjoy all the advantages which the occupancy of land can confer on a labourer. And there is not a more useful, we may also add, a more comfortable, body of men among the industrious classes of society.

To give this class of labourers four acres of land, along with every cottage, would be to render them bad servants, and worse farmers; and either a nuisance to the person on whose farm they reside, or his abject dependents for employment. The only proper residence for men who do not choose to engage, or are not wanted, as constant labourers, is in such central agricultural villages as we have just mentioned, and not on separate farms, where they are excluded from the general market for labour.

But it is needless to proceed further with this discussion. Of all the witnesses examined before the late Committees of Parliament on the corn laws, there is only one whose sentiments are opposed to the general feeling of all well-informed men, regarding the advantages that have resulted from the enlargement of farms. We shall, therefore, content ourselves with noticing what appears to be the natural progress in the size of farms,—the circumstances which prevent any possible enlargement of them from ever becoming injurious to the public,—and the influence which perfect liberty in this respect has exerted in the improvement of our agriculture.

Progress in the Size of Farms.

During the feudal system, that part of an estate which was not cultivated under the direction of the proprietor himself, was let out in small allotments to his vassals, from whom he received military or other services, or a portion of the produce, in return. In these times of turbulence and ferocity, the power of the chief mainly depended on the number of his tenants; and it was therefore his policy to increase them as much as possible, by dividing his land into very small possessions. That they might assist one another in their rural labours, and in repelling the incursions to which they were incessantly exposed, these tenants were collected in a village near the castle of their lord. A certain extent of arable land was appropriated to it, on which they raised corn, and a much larger tract of waste or wood land, where their live stock pastured in common. Spirited cultivation could never be introduced into this system of occupancy; nothing more than the means of subsistence was sought by the tenantry, and power, not revenue, was the great object of the landholder.

For a long time after the fall of the feudal system, this arrangement continued to prevail with little alteration; its vestiges are still to be traced in every part of Britain; and it exists in several counties, though in a modified form, even at the present time. The common fields and commons of England, and the *infield* and *outfield* divisions of Scotland, did not originate in any regard for the welfare of the lower classes, to whom the tenancy of land is now thought to be so necessary, but in the anarchy and oppression of those dark ages in which all the landed property of the island was engrossed by a few great barons.

When these petty sovereigns were at last overthrown, and when commerce and the arts held up to them new objects of desire, and to their depressed tenantry new modes of employment and subsistence, the bond which had hitherto connected the landholder and cultivator became more and more feeble, and it was soon found necessary to establish it upon other foundations than those of feudal protection and dependance. The connection between landlord and tenant came gradually and generally to assume that commercial form, which is at once most conducive to their own interest, and to the general welfare.

One great obstacle to this change was the want of capital ready to be embarked in agricultural pursuits. Under the feudal system there could be little or no accumulation. Property in land was the only means of obtaining the command of labour, and a share of the produce its only recompense. Accordingly, upon the breaking up of the feudal system, large tracts were taken into the immediate possession of landholders themselves, because no suitable tenants could be found. The constant superintendence required in cultivating corn-lands, as well as the absurd restrictions of those times upon the corn-trade, and the constant demand for British wool on the Conti-

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nent, occasioned these tracts to be laid to grass and pastured with sheep. Hence the grievous complaints, during two centuries, of the decay of husbandry and farm-houses.

But this resource of land proprietors was effectual only on soils of an inferior description; on good arable land, the only method by which a part of the produce could reach them in the shape of rent was, to enlarge their farms. The old occupiers were too numerous to spare any considerable part of the produce, and generally too indolent and unskilful to make any great exertions to augment it. In these circumstances, the landholder must either have virtually abandoned his property, or reduced the number of its inhabitants, who were no longer permitted by law to make him that return which had been the original condition of their tenures. But the population of the towns was now gradually increasing, and it was necessary, for the supply of their wants, as much as for the benefit of the landholders, that a large disposable produce should be obtained from the soil. The measure of enlarging farms was, therefore, in every view, indispensable. Even such of the tenants themselves, as it was necessary to displace, might have felt but a slight and temporary inconvenience, had the change been gradual. Some of them would have found employment in towns, and others as hired labourers and artisans in the country. The dismission of the small tenants seems, however, to have been the occasion of much misery; for, in the sixteenth century, manufactures and commerce had made comparatively little progress in Britain. In the present times, any length to which the private interest of landholders could operate in this manner, would, in a national point of view, be too inconsiderable to deserve notice.

It is in this way that farms have been enlarged. The most skilful and industrious of these small tenants were naturally preferred, and their possessions afterwards enlarged as their capital increased. The consequence everywhere has been, a better system of cultivation, affording a higher rent to the land proprietor, and a greater supply of land produce for the general consumption.

Cannot become too large.

But it is only for a time, and to a very limited extent, that the enlargement of farms can proceed. The interest of the landlord, which gave the first impulse, is ever vigilant to check its progress, when it is attempted to carry the measure beyond due bounds. It is in this that the security of the public consists, if it were ever possible that the public interest should be endangered by the enlargement of farms. Accordingly, in most of our counties, a few tenants, of superior knowledge and capital, have been seen to hold considerable tracts of land, which, after a few years, were divided into a number of separate farms. The practice of these men is a lesson to their neighbours; and their success never fails to bring forward, at the expiration of their leases, a number of competitors. Whenever skill and capital come to be generally diffused, there can be few instances of very large farms, if a fair competition be permitted. No individual, whatever may be his fortune and abilities, can then pay so high a rent for several farms, each of them of such a size as to give full room for the use of machinery, and other economical arrangements, as can be got from separate tenants. The impossibility of exercising that vigilant superintendence, which is so indispensable in agricultural concerns, cannot long be compensated by any advantages which a great farmer may possess. His operations cannot be brought together to one spot, like those of the manufacturer; the materials on which he works are seldom in the same state for a few days,—and his instruments, animated and mechanical, are exposed to a great many accidents, which his judgment and experience must be called forth instantly to repair.

It has been said, indeed, that a great farmer may pay a higher rent, because he saves the family expences of a number of small tenants. But from what fund do these tenants maintain their families? It ought to be either from the profits of their capital, or the wages of their labour, or from both combined, and certainly not from the landlord's just share, in the shape of an abatement of rent. If they cannot pay so high a rent, it must be because their capital and labour are less productive to the public than those of the large farmer. Such men might, in most cases, be employed with more advantage, even to themselves, in some other profession.

The proper size of Farms determined by the amount of Rent settled by competition.

The various other reasons assigned for the great enlargement of farms, are equally nugatory. There is generally no saving to the landlord in buildings and fences; and a very small difference of rent will pay for the trouble of keeping accounts, and settling with twenty tenants instead of one. The fact certainly is, that the principal, if not the only reason, why farms have been enlarged, is, the higher rent paid by their occupiers. To pay this rent, they must bring to market more produce; and this they are enabled to do, by the distribution of their crops and live stock to suitable soils and pastures; by an economical arrangement and regular succession of labour throughout the year; by the use of machinery; and, still more than all, perhaps, by the investment of capital in those permanent improvements, which augment both the quantity and value of their products. Rent, in fact, is an almost unerring measure of the amount of the free produce; and there is no better criterion for determining whether a tract of country be laid out in farms of a proper size, than the amount of the rent paid to its proprietors. Their interest is, in this instance, completely identified with that of the great body of the people.

Size of Farms different according to the Nature of the Land.

If we examine the various sizes of farms, in those districts where the most perfect freedom exists, and the best management prevails, we shall find them determined, with few exceptions, by the degree of superintendence which they require. Hence pastoral farms are the largest; next, such as are composed both of grazing and tillage lands; then, such rich soils as carry cultivated crops every year; and, finally, the farms near large towns, where the grower of corn gradually gives way to the market-gardener, cultivating his little spot by manual labour. The hills of the south of Scotland are distributed into farms of the first class; the counties of Berwick and Roxburgh into those of the second; and the smaller farms of the Lothians and of the Carse of Gowrie,

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where there seems to be no want of capital for the management of large farms, are a sufficient proof of the general principle which determines the size of farms.

It must readily appear from these remarks, in what manner the enlargement of farms, or rather the absence of all restraint upon the transactions of the landholder and farmer, has promoted the improvement of our agriculture. To confine the practice of this important art to the manual labour of men in a state of poverty and dependence, would be no less injudicious, and much more ruinous in a national point of view, than to destroy all the extraordinary inventions for saving labour in our manufactures. The effects of capital and machinery are the same in both departments. But no man of education, and in circumstances much above the condition of a common labourer, would ever engage in farming, if his concerns could be no farther extended than to fifty or one hundred acres held at rack-rent; and on such farms, there is no room for the most economical machinery,—for convertible husbandry, by which land is preserved in its highest fertility,—or, indeed, for any of those arrangements, which approach in their effects to the division of labour in other arts.

Besides those general causes of the improvement of the agriculture of Britain, arising from the division of landed property—the existence of a distinct class of professional farmers, whose rights are secured by leases, and whose exertions are stimulated by a rent settled by competition—and the opportunities held out for the investment of capital as far as it promises to be profitable,—there are several others of a more limited or temporary nature, but which it is only necessarily barely to mention. The most important of these is the extent of the British market, which, for many years, has required more corn than was grown in the country. The gradual rise of price, which was the necessary consequence of this, and still more the enormous prices of several late years, in which foreign supplies were obtained with difficulty or altogether withheld, have contributed in no small degree to the improvement of our own ample resources. This has been further promoted by the facility and expedition with which commodities of every kind are transported by means of canals, roads, and railways. And the liberal accommodations afforded by the banking establishments, have enabled British farmers to operate upon extensive wastes, of which the improvement must be advantageous to the public, even though, should these temporary aids be withdrawn, it may not be profitable to themselves.

Markets.

Canals, &c.

Banks.

Rapid progress of Agriculture in Scotland.

The progress of a correct system of agriculture, has been far more rapid in Scotland than in England; the effects, at least, have been more conspicuous. Not only the rents paid in Scotland, but the actual produce per acre, and still more the disposable produce, seem to be greater than in England, wherever the comparison is made with land of a similar quality, and with an allowance for the difference in climate and markets. This remark naturally leads us to advert to some circumstances, which seem materially to impede the agricultural improvement of the country, particularly the southern half of it; and with one or two observations on this head we shall conclude this article.

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The low state of agriculture in many parts of Britain, with the great advance in the price of corn within the last twenty years, on the one hand, and the abundance of capital, displayed in the manufactures and commerce of the country, as well as in the immense sums lent to government, on the other, are circumstances sufficient to convince every reflecting mind, that there is no want either of means or of inducements to the improvement of our territory. It is impossible, indeed, to travel through the country in any direction, without feeling a strong conviction that there must be some serious obstacles to the investment of capital in agriculture. The circumstances which seem to have the most weight in determining men of capital to engage in any particular profession, are the security and productiveness of that capital, the power of transferring it, and the degree of estimation in which the profession is held by the public. To the absence of these essential requisites we must ascribe the backward state of this art, notwithstanding all the other motives, both of a public and private nature, which have long existed for its advancement.

Obstacles.

To the class of drawbacks upon agriculture, and impediments to its improvement, belong tithes,—poor-rates,—payments in the shape of fines, and services exacted by the lords of manors,—entails,—tenancy at will, or on very short leases,—unfair restrictions on the tenant as to the disposal of his lease, and as to the management of the lands during its currency,—the game laws,—and the complicated regulations under which commons and common fields are cultivated, and the great expence required to place them in a state of severalty.

Tithes.

It appears, that nearly three fourths of the lands of England and Wales, are exposed to claims which wrest from the husbandman one-tenth of the gross produce of his labour and capital, and this, whether the remainder of the produce be or be not sufficient for his remuneration. Though no rent were paid for poor soils, this burden alone would effectually prohibit their correct cultivation; and even in the case of rich soils, tithes diminish the rent so considerably, as to make it the interest of landholders, in many parts of England, to restrain their tenants from converting grass lands into tillage; that is, from placing them under the most productive management for the community, both in regard to the supply of food and of employment.

Nothing required but the removal of obstacles.

To the enlightened inquirer it must appear abundantly clear, that all plans for the extension and improvement of British agriculture must prove ineffectual, so long as these capital obstacles are left untouched; and that their removal is all that need be done, and all that ought to be done by a wise government, for securing an abundant supply of the first necessaries of life. Let all land be held and occupied in severalty,—let it be exempted from all indefinite exactions, particularly such as diminish, or altogether absorb the just returns of capital and industry,—let the connection between the land proprietor and the farmer be everywhere formed upon equitable principles, to the exclusion of all remnants

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of feudal ideas, all notions of favour and dependence, and all obligations that do not appear within the four corners of the lease itself, or are not imposed by the general principles of law,—let the rights of a tenant be so far enlarged as that he may be enabled at pleasure to withdraw his capital by a transference of his lease, and to regulate the succession to it after his death,—then there can be little doubt, that a large part of the disposable capital of the nation, now embarked in much less profitable pursuits, would, of its own accord, turn towards the improvement of our lands; and thus furnish employment and subsistence for our population, secure from the caprice of fashion, and the rivalship and jealousy of other countries. (A.)

## EXPLANATION OF THE PLATES.

### Plate I.

Swing-plough. Grubber. Drill-Harrow. Common Harrows. Improved Harrows.

Figures 1 and 2 are different views of the *Swing-plough*, made wholly of iron; fig. 3, the body in one entire piece of cast-iron, which is attached to a wooden beam with screw-bolts. Fig. 4, a plan of the *Grubber*, the inner frame made to rise upon hinges, so as to keep the tines or coulters from the ground, when it is removed from one field to another, and supported by iron stays. Fig. 5, section of the same, the forewheel dragged in going down hill. Fig 6, three different views of the coulters. Fig. 7 and 8, *a Drill-harrow*, to work between the rows of plants, and made to contract or expand according to the width of the interval. Fig. 9, 10, *Common harrows*, each drawn by its own horse, though two and often three work together. Fig. 11, and 12, *Improved harrows*, in general use for covering grass seeds, by which all the ruts or tracks are made equidistant. See p. 114.

### Plate II.

Draining Plough.

Fig. 1. Elevation of a *Draining plough* drawn with a horse windlass, in which AB is the beam, C the coulter, and D the stem of the mole *a* : *b* is a small roller placed at the end of the beam, to keep the mole always at a regular depth beneath the surface. E, the handles, attached to the end of the beam by a bolt, on which they move so as that they may be set at any required elevation, having an iron sector *c* to confine them, by a pin which fastens it to the end of the beam; and there are several different holes in the sector. F is a wheel or roller, to support the end A of the beam; it is fitted in iron pieces, descending from the frame G, which, at one end, is fastened to the beam AB, by a bolt passing through all the three pieces. The frame G has an arch *d*, fixed to it, which passes through the beam, and is pierced with holes to fix the beam at any required elevation. The two pieces G are so inclined, that they will be sufficiently distant from each other at the front end, to form the sides of the frame which admits the windlass or roller K to work between them. Upon this windlass, the chain L is wound, when the windlass is turned round by the wheel and pinion Z, with two handles X, as shewn in the figure. A cross piece is framed between the two pieces G, and into this the iron arch *d*, and the wheel irons F, are fixed in the front. There is also an iron bolt extended from one piece G to the the other, so that a frame is formed for the roller. The great chain L is passed through a block or pulley M, which is hooked into the eye, at the end of the shank of the anchor N, and the other end of the chain being conducted back to the plough, is hooked to a piece of notched iron fixed in the beam, behind the stem D of the share; by this means this windlass has a double purchase to draw the plough forwards with the greater power.

In the use of this plough, the anchor is carried forwards, to the extent of the chain L, and being held by one man, with its point on the ground, whilst another man turns the windlass, it draws itself into the ground, which the other aids by striking it with a beetle or large mallet.—Fig. 2 shows the form of the drain made by the pressure of the iron cone or mole, without throwing out any earth, no other mark being left on the surface, than the small opening through which the coulter passed, which closes in a few days.

Fig. 3. Another plough of the same description. A, a wheel coulter turning in a long mortise made through the beam B, just before the stem *a* of the mole *b*. This wheel being made sharp upon its circumference, cuts the same opening as a coulter would, but with less friction. D, a roller at the end of the beam.

Fig. 4 is a similar machine with an improved capstan; EE, the wheels to keep the drain always at the same depth; F, the coulter; G, the stem or share, adjustable by wedges or pins in the beam K; H is the mole fixed at its lower end; L, a roller to regulate the depth of the drain; M, the handles which are moveable by means of the pin *g*; *a*, a hook with notches, by which the point of the draught is altered in height, and it is carried to the right or left by the notches in the frame *b* (see fig. 5.), into which the chain of traction is hooked; *c* is a piece of iron attached to the beam between the wheels EE, to keep the chain in its place; *d* (fig. 5.) is an iron spindle for the wheels to turn upon; *f* an eye to prevent the chain from falling down, and *e* is a pin to keep the spindle *d* from turning. The horse is harnessed to the lever X, and, as he walks round, turns the axis Y, which communicates motion to the capstan A by the cog-wheels R W. NN are two wheels for the support of the frame of the capstan, and a third wheel, P, is situated at the end of the pole O, being fixed in a piece of iron *r*, which can be raised or lowered through the pole to incline the axis of the capstan from the perpendicular, that the chain of traction B may wind upon the capstan regularly from one end to the other. By these three wheels, the capstan is also adapted to uneven ground, raising or lowering the roller P, through the end of

Explanation of the Plates.

the pole O. Z is an anchor connected with the pole O by a chain *n*, or by two chains, if the strain renders them necessary, by which the capstan is prevented from being moved by the force of the draught.

The manner of removing the capstan and frame is this: Suppose the chain wound up upon the capstan, and the plough, as shewn in the figure, drawn up as near the capstan as it can move, without interfering with the horse path,—the horse is unhooked from the end of the lever X, and put to a ring in the shank of the anchor at *m*, by which he raises the anchor, and draws along the capstan upon its wheels NN, the chain or rope B unwinding from the capstan as it recedes from the plough. When all the chain is unwound in this manner, the horse is taken back to the lever X, which he begins to turn round, and thus winds up the draught chain B, during which the anchor and the stays *l l* are again fixed in the ground.

Figs. 8, 9, are segments or cases of wood, which are employed to increase the diameter of the capstan; the chief advantage of this machine over others of the same kind, being the variety of powers which it possesses.

Plough for making open Drains.

Fig. 6 is a *Plough for making open drains*. The share A has a coulter B fixed to it, projecting upwards, to cut one side of the drain; which, when finished, will be as represented in fig. 7; D is another coulter fixed to the beam, and also to the share at the lowest end. The sod which is thus cut out, passes between the coulter D, and the mouldboard E, which lifts it clearly out of the trench; E and F are wheels, which, being fixed to irons *a*, regulate the depth to which the drains shall be cut. The beam, handles, and other parts, are evident from the figure. This plough is drawn sometimes by four, and sometimes by six horses, and may form a drain from five to nine inches deep.

PLATE III.

Machine for sowing Turnips.

Fig. 1. *A machine for sowing turnips*. A, cover of seed canister, held up to shew it. B, seed canister, with holes on the circumference at the middle part *a*. These holes can be enlarged or diminished by means of a broad tin ring, which can be moved round the canister, (see Z on the figures apart). C, second seed canister with cover; DD, tin funnels, through which the seed falls to the coulters EE; FF, a piece of iron fixed to the handles HH, and to the coulters to regulate their force; II, wheels at both ends of roller L, by which it is supported; KKK, communicating wheels from the axis of roller L, to the axis of the seed-canisters BC; L, roller for flattening the top of the ridge before the seed is deposited; G, another roller which assists in covering it by compressing the earth opened up by the coulters. See page 116.

Double mould-board Plough.

Fig. 2. ABC, a *Double mould-board plough*, with its mould-boards taken off, and expanding wings applied with circular coulters, for paring the edges of the drills; DD, the expanding arms, which are removed when the mould-boards are put on; EE, the circular coulters; P, a back view of a coulter; F, a scuffle, two of which are applied at pleasure, in place of EE, the circular coulters. Fig. 3, GG, the mould-boards taken off. Fig. 4, a *One horse paring-plough*, to which the beam and handles AC (fig. 2.) are applied when taken from the body B. and secured by three screwed bolts, at 1, 2, 3; I, the coulter for the paring plough. Fig. 5, A *Drill harrow*, to which also the beam and handles AC (fig. 2.) are applied in the same manner; KKK, scuffles or hoes, which may be applied to the harrow in place of tines. Fig. 6, part of a common plough, with a wheel brake attached; A, the axle screwed to the plough; BB, the screws; C, the wheel, (See page 134). Fig 7, a *Roller* to be worked by two horses a-breast, made of cast-iron.

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Paring Plough.

Drill-Harrow.

PLATE IV.

Cart.

Fig. 1, a close bodied *Two-horse cart* with frames for carrying hay and corn in the straw. The frames at other times are withdrawn.

Apparatus for yoking Horses in Thrashing Mills.

Fig. 2. *Apparatus for yoking horses in thrashing-machines*. AA, the perpendicular axle, in which are fastened the arms BB that carry the great wheel. CDM and EF, the limbers at which the horses draw. Into each of these are placed two running sheeves, as 1, 2, in the limber C; 3, 4, in the limber D, &c. GH, a frame fixed on the axle A and arms B; PR, shifting blocks upon this frame. In each of these blocks are placed two sheeves, over which pass the endless rope or chain P, 5, R, which connect the shifting blocks (see DD and 13 fig. 3.); KLMNO, the hooks to which the horses are yoked, these hooks being fastened on the ropes 1, 3, G, and H, 7, 9. In this manner all the ropes are connected, and of course the power of all the horses united. Fig. 3, A A, the axle in which are fixed the arms BBBB; C C, frames in the axle; 11 and 14, shifting blocks, moveable either inward to the axle or outward from it; D D, an endless rope or chain which passes over the blocks at 12 and 13; EE, two sheeves by which this rope is kept clear of the axle; FF and FF ropes, which pass over the blocks at 11 and 14; GGGG, running sheeves over which pass the double ropes by which the horses draw; HILMN and OP, the limbers (see CD and EF, fig. 2.). Each horse is yoked to two hooks as 1, 2—3, 4, &c. By this means the draught will always press the collars upon the horses' shoulders, whether they incline to pull outward or inward, so that if one of the horses relax, he is thus excited to exertion. The figures represent the machine as worked by four horses, but the same apparatus may be applied to one worked by two or by six horses.

Small Thrashing-Mill.

Fig. 4 is a perspective view of a small *Thrashing-mill* worked by one or two men. Fig. 5, A, the feeding board; B, the rollers; and C, the drum to which the beaters are attached. (See the figures of a thrashing-mill annexed to the Article THRASHING in the body of this work.)

Hainault Scythe.

Fig. 6, a kind of short *Scythe employed in Hainault in Flanders* for cutting the crops; it is used with success for every kind of crop except grass; and has been lately introduced into England by G. H. Rose, Esq. of Muddeford, in Hampshire. ABE, the wooden handle, an inch and a quarter diameter, held in the mower's right hand by the part AB, which is about five inches long. The part BE is 16 to 22 inches long, according to the height of the mowers.

Explanation of the Plates.

At $a$ is a leathern loop, through which the fore finger is passed, and there is a knob at the extremity which would prevent the hand slipping off, if the loop should break or the finger slip out of it. The blade EF is about two feet long and $2\frac{3}{4}$ inches broad at the middle. The handle is attached to the blade at E in such a manner as that its plane makes an angle with the handle BE, by which the mower is able to cut a little upwards, but almost close to the ground, without stooping, while the handle EB, inclines to the horizon about 60 or 70 degrees. The line of the handle AB, if produced, will nearly pass through the point of the blade F, and this gives the means of controlling the point, whilst the forefinger in the loop commands the heel E.—Fig. 7, GH, a light staff terminating in an iron hook I, is used at the same time with the scythe. The mower holds it in his left hand by the middle, the curved part of the hook over the scythe in a similar position to its blade E F, and above it, their points being exactly above each other. In working, the mower moves both together, making the hook to pass behind the straw at about the middle of its height, to separate and bear it slightly down towards the left hand, while the blade follows with a motion from right to left to cut off the straw at two to four inches above the ground.

In order further to explain the process of Hainault mowing, fig. 8 represents the corner of a field of corn, in the process of mowing by three mowers at D E F, who are following each other with their respective swathes. The breadths of corn cut at every stroke, are carried forward by the joint operation of the blade and the hook, and collected at the left hand of the mower, where he leaves them standing almost erect, but leaning to the left against the standing corn as at $n$. When as much is cut as will make a sheaf, the mower turns to the left so as to face the standing corn at $n$, introduces his hook behind the middle of the leaning parcels, and at the same time the scythe point near the bottom, then moving sideways to the left, returning over the ground he has mown, he draws and collects the cut corn, still, by means of the hook and scythe, preserving the erect position of the straw, to the place where the last collecting operation ended; then wheeling round to the left with the hook still embracing the middle of the whole cut corn, he stops the motion of the scythe, whilst the hook still moves forward to the left, so as to overset the corn and lay it evenly along on the stubble, as shewn at $r$ $r$ $r$, with the ears towards the right, ready for the binder. In oversetting the collected corn he uses his left foot if necessary. The mower now advances to the front and commences the cuts for a new sheaf as before, always working towards the standing corn and not from it. With the Hainault scythe, about twice as much corn, it is said, may be cut in the same time, as with the common reaping-hook, and a great deal more of the straw is saved.

### Plate V.

Plucknet's Reaping-machine.

Fig. 1. A perspective view of *Mr Plucknet's Reaping-machine.* AB, the great wheels, having the wheel C upon their axis, to turn a pinion, on the lower end of a verticle spindle, which carries a wheel D; $c$ a small pulley fixed at the upper end of the axis E, of the circular cutter G; F the iron plate for supporting the axis beneath which the cutter is situated; and it is turned over the edge of the wheel A, to guard the standing corn from it; H the handles, K the horse shafts, placed on the left side of the cutter, and fixed to the frame of the machine by hinges, and having irons $b$, with various pin-holes.

Salmon's Reaping-machine.

Fig. 2. is an elevation, and fig. 3. a plan of *Salmon's Reaping-machine.* AA, two large wheels, not fixed fast upon their axle, but having clicks fitted upon the naves, which act in the teeth of wheels, $a$, (fig. 3,) fixed fast to the axis; $b$ is a contrate wheel, which turns a pinion, $c$, (fig. 2,) fixed on the lower end of the perpendicular axle, which, at the upper end, has the cog-wheel D, for the purpose of turning another vertical axis, $d$, by means of a pinion, E. The latter axis has a fly-wheel, F, fixed on the upper end, to regulate the motion, and at the lower end a crank, which, by means of the rod $f$, gives motion to the shears by which the corn is cut. These are marked G, being four in number. The fixed blades are firmly attached to an iron bar, $e$, which is fixed across the frame of the machine, and the moving blades have their centre-pins fixed in the same bar, but the levers or tails are jointed to one iron rod, $g$, which is at one end connected with the rod, $f$, of the crank; therefore, by its revolution, it moves the rod backwards and forwards, and causes all the shears to open and shut together. In order to make the shears cut perfectly, the rod $g$ is suspended by a small iron rod at each end, one of which is seen at $h$ in the elevation, fig. 2; these pass through mortises in the upper cross-rail of the frame, and have nuts upon them, by which they can be made to draw up tho rod $g$, and thus press the cutting parts of the blades together, to make them cut properly, although the rods $h$ are at liberty to vibrate sufficiently for the motion of the rod $g$. The tails of the shears are covered with a sort of table, or platform, of iron plate, omitted in the plan, but shewn edgeways by the dark line H, in the elevation. This plate comes as far as the centre-pins, and turns up against the front of the frame, so as to prevent the corn which the shears cut from falling down into the shears, but the butts, or cut ends of the corn rest upon this plate until a sufficient parcel is collected, and it is then removed sidewise by the rake K. This consists of a light frame of wood, composed of three upright bars and cross braces; it is guided by passing through between two rails, $k$, supported by uprights, $r$, fixed to the frame of the machine, but has liberty to rise and fall, and also to move out of the perpendicular, by means of a light crank, $m$, of considerable radius, which is fixed upon the extremity of a spindle, L, which receives motion by a small bevelled wheel, $l$, upon the end of it, from another bevelled wheel, fixed upon the vertical axis. The consequence of this motion is, that the points of the rake will, as in the figure, rest upon the iron plate H, which covers the shears, and the motion of the crank advancing them across it, they remove the corn sidewise, laying it on the ground. The forward part of the machine is supported by the wheel M, which is fitted in a fork at the lower end of an iron rod N, and this passing through a mortise in the frame, has pin-

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holes to fix it at any required height. This regulates the height at which the shears cut. The wheel M is, in part, sunk into the thickness of the board O, and a piece of iron plate is fixed on the outside of it, to guard the corn from entanglement. The pointed edge of the board O, is made sharp, for the purpose of separating the corn which is intended to be cut, from that which is to be left standing. From this a curved rail, P, is extended, and also made sharp. From the extreme end of the frame a light iron rod, Q, is extended, with a gradual curve, as the figures shew, and it is fixed at the opposite end to the other part of the frame. This rod acts as a stay, and also to gently bend down the heads of the corn, so that the straw may come to the shears in an inclined position, to be removed by the rake.

The machine is guided by a man, who holds the two handles S in the manner of a wheelbarrow, and he has, just before him, a wedge, R, which, being thrust inwards by his knee, will lift up the pinion *e*, (fig. 2,) upon its axle, and thus disengage it from the teeth of the great wheel *b*. In this state the machine can be wheeled without turning the machinery; but, on withdrawing the wedge, as in the figure, the pinion descends to its proper place, and the motion is communicated to the whole machine when it is wheeled along. As the drawing was made from an experimental machine, to which the horse shafts were never applied, they are omitted in the figure, but their application may be easily conceived.

The manner in which the machine operates is evident from the description. The stems of the corn are received in the open shears, being gathered in by pieces of iron plate, *s*, (fig. 3,) which are fixed upon the bar *e*, carrying the fixed blades, and, as these are pointed, they separate the corn, and conduct the whole into one or other of the shears; and it is cut when they close up. The fixed blades of the shears are made double, as shewn in the separate view, fig. 4; and the moving blades, having edges on both sides, cut either in opening or shutting; for, as the machine is constantly advancing, a space must always be left open for the reception of the corn, whilst the parcel already included within the shears is cutting off.

On trial of this machine, it was found that it did not effect a separation when the ears of the corn were entangled by wind, so that the cut corn frequently had an ear or two attached to that which remained standing, by which it was thrown into confusion. But this defect, it is hoped, may be obviated.

### Plate VI.

Smith's Reaping-machine.

Fig. 1 represents a profile of *Mr Smith's Reaping-machine*, complete, and in operation, the near horse and carriage-wheel being however removed, that the view of the framing and gearing may not be obstructed. It will be seen by this figure and fig. 2 (which is a bird-eye view of the machine), that the horses are yoked one on each side of a pole, which runs back from the frame of the carriage. The person who drives the horses and directs the machine walks behind, having command of the horses by a set of common plough reins, and directing the machine by a hold of the end of the pole. The horses draw from a cross bar at the end of the pole by common plough chains, the back-weight of the carriage resting on their common cart-saddles, by means of an apparatus such as is used in curricles. On the fore part of the carriage is hung a horizontal circular cutter, surmounted by a drum, the blade of the cutter projecting $5\frac{1}{4}$ inches beyond the periphery of the lower end of the drum. When the carriage is moving forward, a rapid rotatory motion is communicated to the cutter and drum, from the motion of the carriage wheels, by means of a series of wheels, pinions, and shafts. The diameter of the cutter projects beyond the carriage-wheels on each side, so as to cut a breadth sufficient to allow the carriage and horses to pass along without risk of treading down the uncut corn. The corn being cut by the rapid motion of the cutter, the lower ends rest upon the blade of the cutter, and the upper parts coming in contact with the drum, the whole is carried round, and thrown off in a regular row at the side of the machine. The lower ends taking the ground first, the heads fall outwards, the stalks lying parallel to each other, and at nearly a right angle to the line of motion of the machine. The corn lying thus in regular rows, is easily gathered into sheaves by the hand, or by a rake, fork, or other convenient instrument, and is bound in the usual way.

*Minute Description of the Plate.*

Figs. 1 and 2. A, the frame of the carriage, made of oak, or other strong wood, and put firmly together, by bed-bolts screwed into the cross bars B. C, the pole, made fast to the cross bars. D, a cross bar, at the extremity of the pole, from which the horses pull; this bar is of iron, in order to give sufficient weight on the horses' backs. E, the carriage-wheels, 5 feet diameter, and 6 inches broad in the tread. F, the cutter, 5 feet 4 inches in diameter, composed of six segments bolted to an iron ring, $1\frac{1}{4}$ inch broad and $\frac{1}{4}$ inch thick, which ring is connected to the foot of the upright spindle, Z, by the cross arms, G.—Fig. 6 shews one of these segments on a larger scale; *a* is of hard wood, $3\frac{1}{2}$ inches broad and 1 inch thick; *b b* are of German steel, and of a scythe temper, $3\frac{1}{2}$ inches broad, and $\frac{1}{4}$ inch thick at the back; they overlap the wood, to which they are rivetted, $1\frac{1}{2}$ inch, their upper side being flush with the wood; *c*, a small iron stop, to keep the segments from shifting at the joints; *d*, holes through which the ring-bolts pass. Fig. 5 is a transverse section of fig. 6.—H, figs. 1 and 2, a conical drum of slight tin-plate or basket-work, whose lower periphery is 5 inches within the edge of the cutter, but whose upper periphery extends as far as that of the cutter. This drum is two feet deep, connected to the same ring with the cutter below, and to the spindle above, by another ring, with four arms. The drum is covered on the outside with canvas, on which perpendicular strips of soft rope are sewed, being one inch thick, and three or four inches apart, as shewn at I; these give sufficient friction to carry round the cut corn, whilst, from their softness, they have no tendency to shake or thrash it. The horses are yoked to the cross bar D by common plough

Explanation of the Plates.

chains; an upright rod J, and cross rod K, serve the purpose both of belly-band and back-band, the ends of the cross rod passing through iron eyes, screwed temporarily to the wooden ridge of common cart saddles, which are kept firm on the horse's back by a strong extra girth, L. The breeching-chains are linked to the draught chains. M, a breast chain passing through a ring made fast to the *hames*, and drawn up to an eye N, on the side of the pole. Fig. 4, is an inside view of the naves of the carriage wheels; *a*, a transverse section of the axle; *b*, a ratch wheel made fast on the square of the axle; *c*, catches, moveable on pivots made fast to the nave; *d*, slight springs to keep the catches in gear. By this means the wheels carry the axle in revolution with them when the carriage is moved forward, but move round upon it when the carriage is drawn in a contrary direction. This construction is necessary, to facilitate the turning of the machine. The axle moves in two cast iron seats with caps, on which the frame of the carriage rests. A wheel O, (figs. 1 and 2,) of 24 teeth of $1\frac{1}{4}$ inch pitch, works into an intermediate wheel of the same dimensions. This wheel is in gear of a pinion P of 12 teeth, fast on the end of the cross shaft, Q. At the centre of this shaft, two bevelled wheels, R, with long sockets, are fitted loose. These wheels have each 28 teeth of $1\frac{1}{8}$ inch pitch; in the bosom of these is a double reversing catch, which will be best explained by reference to fig. 3, which is a longitudinal section of the cross shaft with the wheels and catch; *a*, the shaft; *b*, the pinion, P, of fig. 2.; *c*, the bevelled wheels, R, of fig. 2, having long sockets fitted loose on the shaft; *d*, a double catch, which is moveable longitudinally on the shaft, but is carried in revolution with it, by means of the feather *e* upon the shaft, fitted into a corresponding groove in the catch. This catch can be put into gear of either of the wheels at pleasure, by means of the lever, *s*, (figs. 1 and 2,) moveable on a stool at T, and kept to its place when set, by notches in an iron stand at U. Both of the wheels are constantly in gear of a pinion of 14 teeth, V, (figs. 1 and 2,) and *f*. (fig. 3):—By thus reversing the gearing, the cutter and drum can be made to revolve to the right or left, and consequently, will throw the cut corn to either side of the machine at pleasure. On the opposite end of the shaft, W, (figs. 1 and 2), on which the pinion V is fixed, is a bevelled wheel X of 28 teeth, in gear of a pinion Y of 14 teeth on the upright spindle, Z. The velocity is so raised by these wheels and pinions, that the cutter makes 128 revolutions *per* minute, when the machine moves at the rate of $2\frac{3}{4}$ miles *per* hour, the edge of the cutter passing through 32 feet *per* second. The pinion Y has a long socket with a groove, to which is fitted a feather, one inch long, on the upright spindle Z, by which the spindle is moveable up and down in the socket, whilst it is carried in revolution with it. The spindle Z has three bearings, one in a brass bush, *a*, fixed in an iron stay-frame, *b*; a second bearing in a wooden bush with a cap on the front of the cross bar at *c*; and a third in a socket resting on the small wheels, *d*. These wheels serve to keep the cutter always at an equal height from the ground. The particular construction of these wheels, with that of the frame and socket, will be better understood by reference to figs. 7 and 8. Fig. 8. a perpendicular section of the foot of the upright spindle and socket; *a*, the spindle, *b*, the socket; *c*, a groove in the spindle, into which the points of two screw pins, *d*, passing through the sides of the socket, are fitted. These are necessary to keep the spindle in its place, and to bear up the wheels when the spindle is raised. Fig. 7, is a bird-eye view of the wheels and carriage, with a transverse section of the socket and spindle; *a*, the wheels, 14 inches in diameter and 3 inches broad; *b*, the axle, to which is fastened an iron frame, *c*, moveable on a pivot at *d*, on the point of the iron bar, *f*, and in a socket at *e*: the bar *f* is one inch square, having a long ruff at *g*, which is turned and fitted to the eye *e* of the socket, fig. 8. The bar is bent so as to pass close under the cutter at *e*. (fig. 1.) and runs up to the pole, having a joint at *f*. This bar is necessary to relieve the point of the upright spindle of the resistance opposed to the wheels in moving along. The cutter can be placed higher or lower on the spindle, so as to cut the straw to any height, by means of a series of holes through the spindle; pins passing through holes in the sockets of the arms, and the most suitable of the series. The cutter can also be screwed to any height from the ground, from two to eighteen inches, by means of an iron lever, *g*, on the point of which is a brass socket, in which the upright spindle runs, and on which it rests by means of a ruff at *h*. The lever is hung by an iron chain, *i*, passing over a pulley at *j*, and joining two iron rods at *k*, which connect it with a screw box, *l*, which is moved backwards and forwards, by turning round the screw, *m*. To the end of this screw is connected an iron rod, which runs along the upper side of the pole to a bearing at *n*. At the end of this rod is a winch, *o*, of 9 inches radius, by which the person who guides the machine can turn round the screw, and so raise or lower the cutter at pleasure. This is principally of use to raise the cutter when passing over a deep furrow, or in going from one field to another: *p*, is a hollow piece of wood put upon the end of the rod, by which the man holds with one hand when guiding the machine. In most cases, the cutters will cut $\frac{1}{4}$ of an acre without requiring to be sharpened, which can be done in two minutes by a common scythe stone, two of which are conveniently carried in two leather pockets, *q*, fig. 2. When it is necessary to go with the machine to a distance, the upright spindle, with the drum and cutter, are taken from their place, and placed on the top of the carriage; and the small wheels are drawn close up to the cross bar. The draught bar, D, is taken from the end of the pole, and placed near the frame of the carriage in the mortice, *r*, fig. 1. The horses are turned to draw from it, and can in this way travel any distance, and over any roads.

We are happy to learn that this ingenious machine has been again tried (in September 1815), and with much success. A Scotch acre ($1\frac{1}{4}$ acre English) of beans was cut down with ease in an hour and a quarter. The trials made with it on wheat, though not extensive, were satisfactory; and in reaping oats, the corn was laid down in the most regular manner, at a right angle to the path of the machine.

Explanation of the Plates.

### Plate VII.

Farm-houses.

The names of the different figures, and of the divisions of fig. 5, being marked on the engraving itself, no further explanation can be necessary. (See page 119.)

### Plate VIII.

Bone-mill.

Figs. 1 and 2, are two elevations of a *Bone-mill*, the first being taken in front, to shew the water wheel and the length of the rollers, and fig. 2. at the end, to shew the bones passing through the rollers;—The water wheel, AA, is represented as being of the overshot kind; it is included between the two walls, BB, upon the top of which, the pivots or gudgeons of its axis are supported in brass bearings. A square formed on the end of one of the gudgeons, is received into a square socket, at the end of the connecting axis, D, which communicates the motion to the lowest, F, of the two rollers, the latter having a similar square on the end of its axis, to be received into the socket at the end of the connecting axis, D. The rollers are supported by a wooden frame, GG. Two iron frames, HH, are bolted down upon it, having grooves, or openings in them, of nearly the whole length, to receive the brasses for the pivots of the rollers, as shewn in fig. 2. At the upper ends of these grooves, are screws, *h h*, by which the rollers can be made to act at a greater or less distance from each other, as the size of the bones which are to pass through them require. Two pinions, *k*, *l*, are placed upon the ends of the axles of the two rollers, and by their teeth acting together, they compel the two rollers to accompany each other. The surfaces of the rollers are filled with indentations and strong teeth, which penetrate and break the bones to pieces. This is accomplished, by employing separate cast iron wheels placed side by side upon an axis, to compose the rollers; the wheels have coarse teeth similar to those of a saw, or ratchet wheel; each wheel of the lower roller, F, is an inch thick; and they are placed at distances of an inch and a half asunder, having circles of hard wood or iron, placed between them, which are two inches less in diameter. Thus they leave grooves, between the toothed wheels, which have the effect of rendering the teeth upon the surface of the roller insulated. The wheels of the opposite roller, E, are $1\frac{1}{2}$ inch wide, and the spaces between them only 1 inch; and the two are so situated, with respect to each other, that the teeth upon one, are opposite to the spaces between the teeth of the other, as is clearly explained by the figure. A hopper, II, is fixed above the machine, over the rollers, and into this the bones are filled, so that they rest upon the two rollers, and are drawn in by their motion, the teeth penetrating and breaking every piece however large or solid it may be. The bones should be supplied rather gradually to the machine at first, to avoid choking it, and the rollers should then be adjusted to a considerable distance asunder; but when the bones have once passed through in this way, the rollers are screwed closer by the screws, *h h*, and the fragments ground a second time. This will generally be found sufficient, as it is not advisable to reduce the bones to a state of extreme division. The pinions must have deep cogs, to enable them to take deep hold of each other, when the rollers are set at only half an inch distance to grind fine, and without the cogs being liable to slip when the centres are separated, so far as to leave a space of 1 inch, or $1\frac{1}{4}$ inches, between the rollers, for the passage of the large bones the first time. The rollers will act most effectually, if the different wheels are fixed upon their axles in such a position, that the teeth will not correspond, or form lines parallel to the axes, and then no piece of bone can escape without being broken by some of the teeth. The bones which have passed through the rollers, slide down the inclined board, R, and collect at the bottom in a large heap. When all the stock of bones are thus coarsely broken, a labourer takes them up in a shovel and throws them again to the hopper, to be ground a second time.

Machine for grinding Potatoe Flour.

Fig. 3. A *machine for grinding Potatoe Flour.* A, a cylinder covered with tin-plates, pierced with holes, so as to leave a rough surface, in the same manner as the graters used for nutmegs, &c. but the holes in this are larger. This cylinder is situate beneath a hopper B, into which the potatoes are thrown, and thence admitted into a kind of trough C, where they are forced against the cylinder, which, as it revolves, grinds the potatoes to a pulp. Motion is given to the machine by a handle fixed upon the end of the axis of the grating cylinder A, and on the opposite extremity of this axis is a fly-wheel D, to regulate and equalize the movement. The potatoes, when put into the hopper, press by their weight upon the top of the cylinder, and, as it revolves, they are in part grated away. On one side of the lower part of the hopper is an opening, closed or opened, more or less, at pleasure, by a slider *d*, and the degree of opening which this has regulates the passage of the potatoes from the hopper into the trough C. This is as wide as the length of the cylinder, and has a concave board R fitted into it, which slides backwards and forwards by the action of levers *a*, fixed to an axis extended across the frame of the machine, and a lever N is fixed upon this axis, and carries a weight which acts upon the board R, by means of the levers, to force or press forwards the potatoes contained in the trough C against the cylinder, and complete the grating of them into a pulp. The tin-plate covering the cylinder is of course pierced from the inside outwards, and the bur or rough edge, left round each hole, forms an excellent rasping surface.

Potatoe-scoop.

Fig. 4. A *Potatoe-scoop*. A, The end of the handle, having a round stem, which passes through a piece of metal D, and has then a semicircular knife or cutter E fixed to it. This is sharp on both edges, and turns upon a pivot, shewn by the dotted lines, fitted in a similar piece of brass to D, which, as well as the latter, is formed out of a piece of plate BC. This forms a shield to hold the instrument firm upon the potatoe, by placing the thumb of the left hand upon the shield BC, and pressing the points of D into the root, which is grasped in the hand; then, by turning the handle half round with the right hand, the semicircular knife makes a sweep, and cuts out a piece or set, which is a segment of a small sphere. Fig. 5. is an end view of the shield BC, and the knife E, also the piece of brass D, placed upon the surface of a potatoe F, in which the dotted line FG shews the piece the knife will cut out by its motion. The

Explanation of the Plates || Index.

only attention necessary in the use of this tool is, that it is placed upon the potatoe, with the eye or part from whence the shoot springs in the centre of the semicircle of the knife, when it is laid flat upon the root. The advantage of this scoop, besides that it is very quick in its operation, is, that the pieces, being all of one exact size, which is about one inch diameter, they can be planted, by a bean-barrow or drill-machine, with much less labour, and more accuracy, than by the hand.

Machine for levelling land.

Fig. 6. A *machine for levelling land.* D, a pole to which the horses or oxen are harnessed, jointed to the axle-tree E, of a pair of low wheels AA. Into this axle-tree are mortised two long side-pieces GG, terminating in handles BB. Somewhat inclined to these long or upper side-pieces, shorter lower ones, HH, are jointed by cross pieces, and connected by strong side-boards. The machine has no bottom; its back part F is strongly attached to an axle C; to the bottom of this back-board, the back or scraper part *d* of a strong iron frame *a a* is firmly screwed, as shewn in fig. 7, and the front ends of the slide-iron *b b* turning up, pass easily through mortises in the upper side-pieces G, where, by means of pins, the inclination of the slide-irons, and of the back-board, can be adjusted within narrow limits, according to the nature of the soil to be levelled, and the mass of earth previously loosened by ploughing, which the back-board is intended to collect and force before it, until the machine arrives at the place where it is intended to be deposited. Here, by lifting up the hinder part of the machine, by means of its handles, the contents are left on the ground, and the machine proceeds to a fresh hillock.

Plates IX. X. XI. XII. XIII. XIV. are sufficiently explained in the Chapter on LIVE STOCK, from which the necessary references are made to these plates.

# INDEX.

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D'Augesseau.

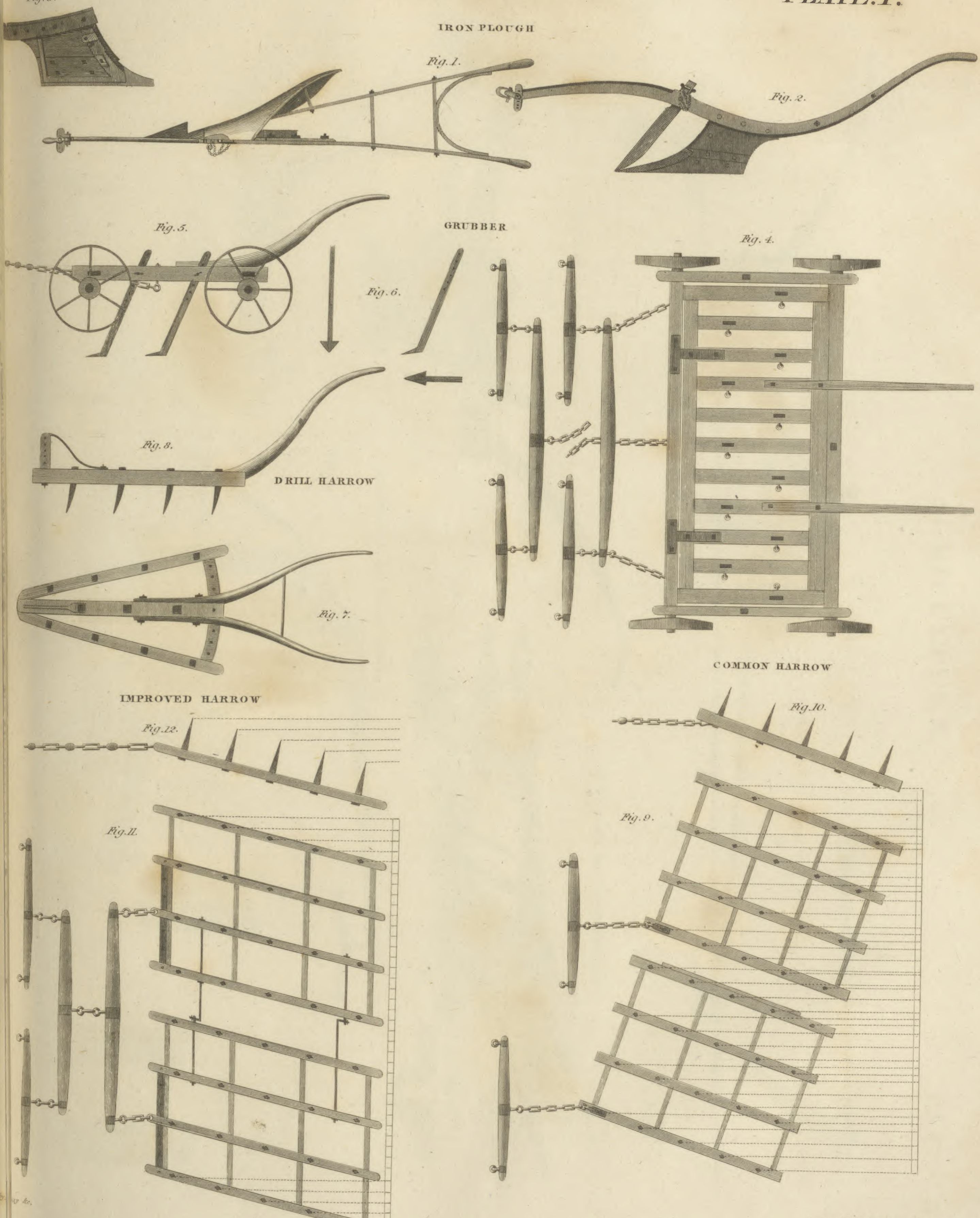
AGUESSEAU (HENRY FRANCIS D'), a Chancellor of France, illustrious for his virtues, learning, and talents, was born at Limoges on the 27th of November 1668. His father, at that time Intendant of Languedoc, and afterwards a Counsellor of State, was a man of great worth and abilities. He seems to have taken the sole charge of his son's education; and having destined him for the Bar, he took uncommon pains to exercise him in every branch of knowledge which could contribute to his success in that profession. His care was rewarded with the happiest success. Young D'Aguesseau gave early indications of uncommon abilities; and such was his thirst for knowledge, and his habits of application, that he soon acquired the reputation of an almost universal scholar. He had a particular relish for poetry, which, he used to say, "was the only passion of his youth;" but this passion was so far from withdrawing him from severer studies, that it was allied in his mind with a nearly equal taste for mathematics. He studied law with the zeal of an antiquary, and the spirit of a philosopher; and, in order to form his taste as a pleader, he employed a whole year in repeated perusals of the most esteemed productions of ancient eloquence. After this thorough course of preparation, he became an advocate in 1690; and, by the interest of his father, who now resided in Paris, he was soon furnished with opportunities of distinguishing himself, and of rising to the highest honours of the profession. When little more than twenty-one years of age, he was appointed one of the three *Advocates-general*;—an office which imposed the duty of assisting in those causes where the king, the church, or the public were concerned. The king, (Louis XIV.) in appointing him, yet untried, to this situation, acted solely upon the recommendation of the elder D'Aguesseau, "who was incapable," said Louis, "of deceiving him, even to advance his own son." D'Aguesseau's first appearances as an advocate-general were such as amply to fulfil the expectations of his father, and to warrant the appointment which he had obtained from the king. Denis Talon, an old lawyer, who had long officiated, with great reputation, in the same capacity, was heard to say, "that he should have been glad to have finished his career as that young man had begun."

D'Aguesseau held this office for ten years; during which period he greatly distinguished himself, both for learning in his profession, and for a superior style of forensic eloquence. He was, indeed, one of the first reformers of the language of the French bar, which had not yet taken much polish from the national improvements in taste and literature. His diction, both in his pleadings and in his juridical compositions, was that of a mind expanded by a liberal course of study, and refined by a familiar acquaintance with classical models. The society which he chiefly frequented was also well adapted to improve his taste; for the chosen companions of his leisure hours were Racine and Boileau; the latter of whom has frequently mentioned him with praise in his writings.

It was D'Aguesseau's opinion, that no one could rise to distinguished eminence as an orator, who did not labour to enlarge and polish his mind by the study of philosophy, and by exercises of literature; and he accordingly employed several of those stated discourses, which the usages of France required from the advocates-general at the opening of the sessions,

# AGRICULTURE.

PLATE. I.

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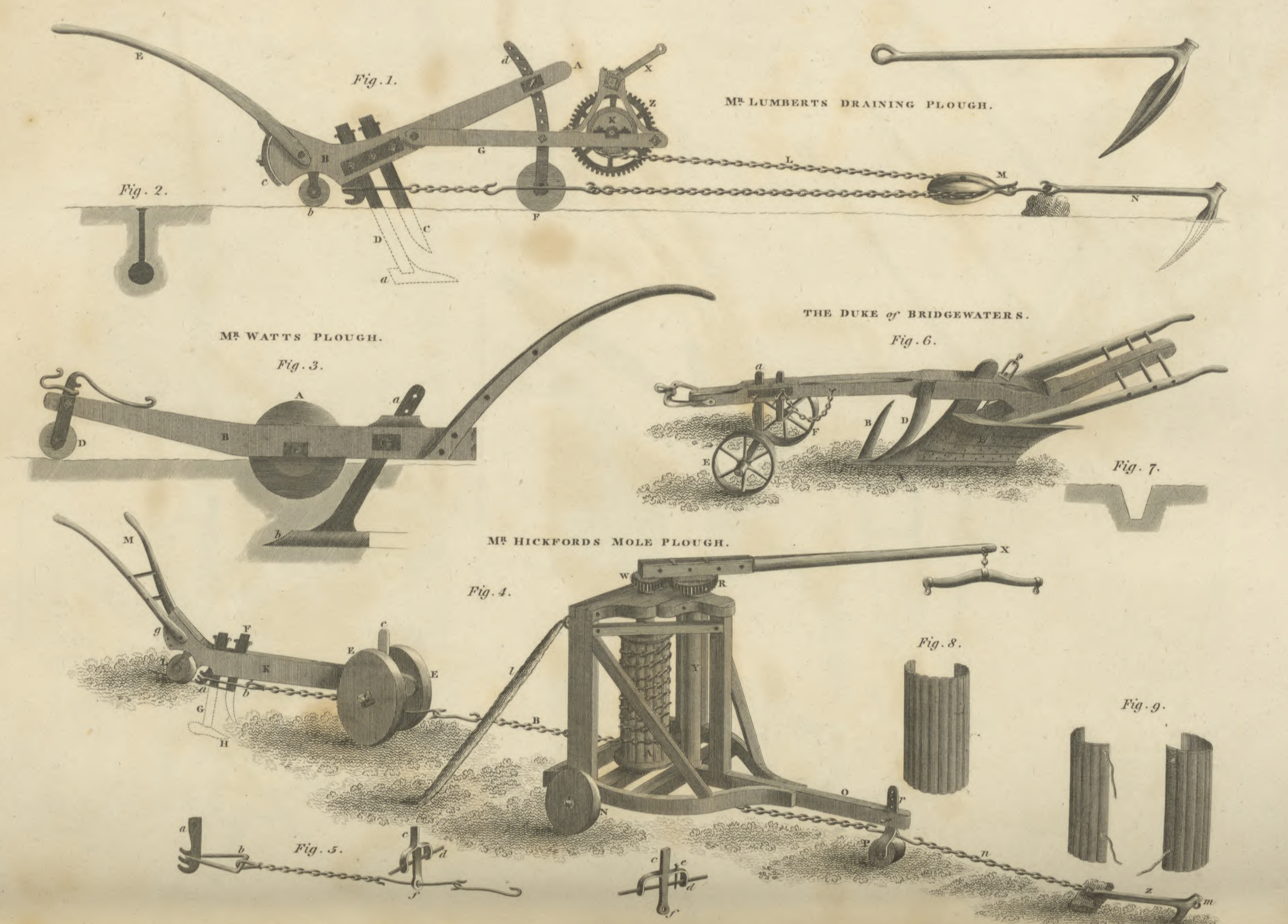
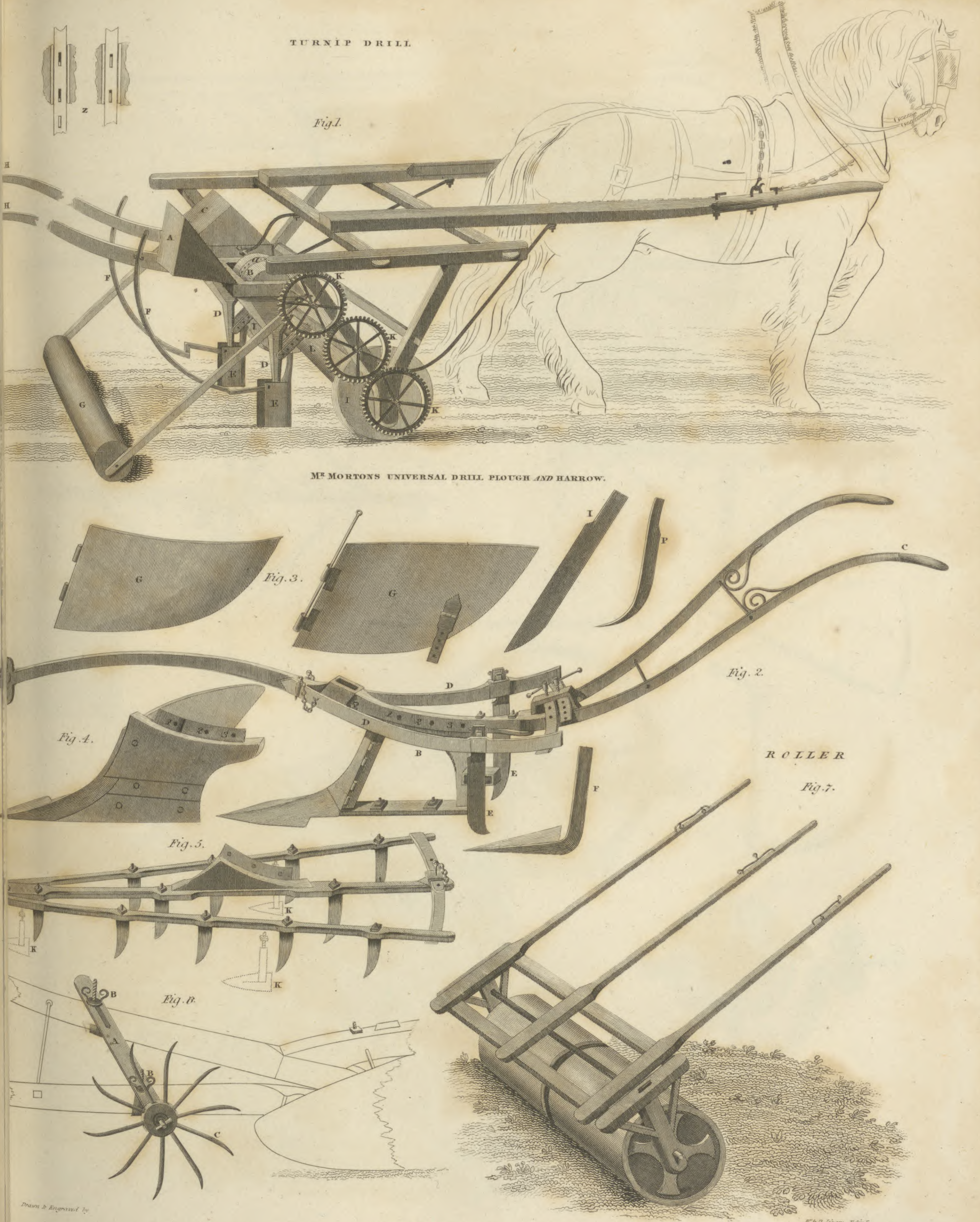
# AGRICULTURE.

PLATE. II.



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CLOSE CART *with* CORN & HAY FRAME.

*Fig. 1.*

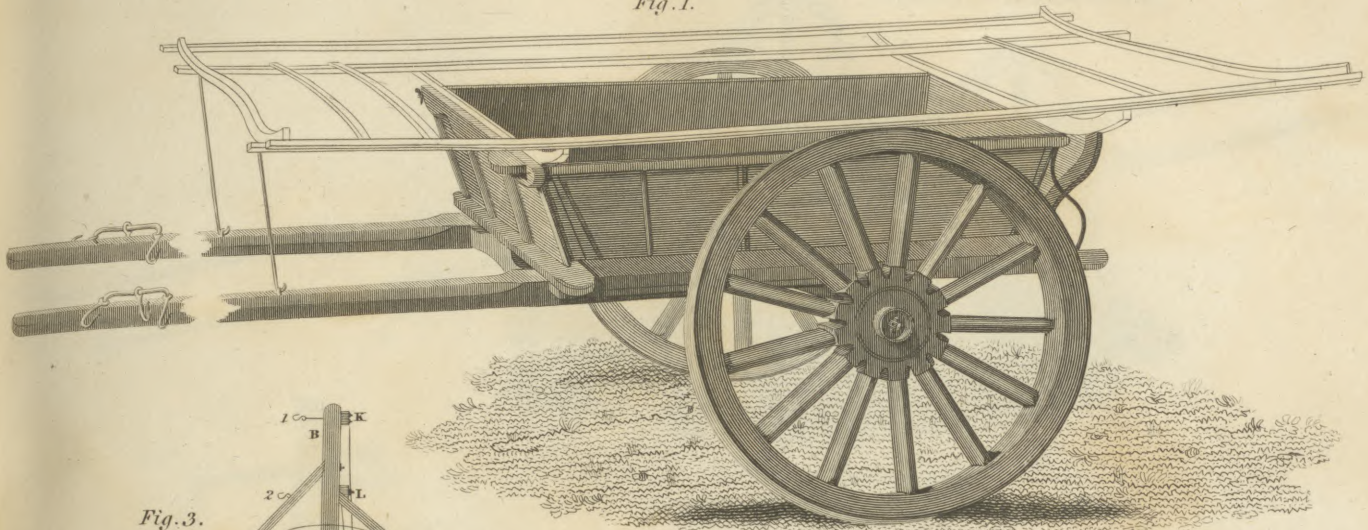


*Fig. 3.*

APPARATUS *for* YOKING HORSES *in* THRASHING MACHINES.

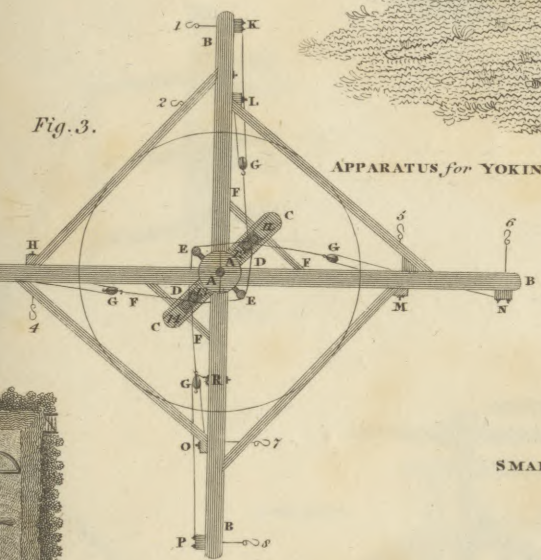



*Fig. 2.*

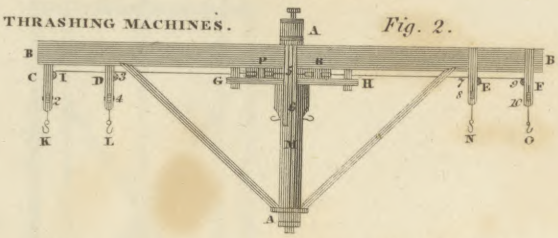



*Fig. 8.*


HAINAULT SCYTHE

*Fig. 7.*


SMALL THRASHING MACHINE.

*Fig. 6.*

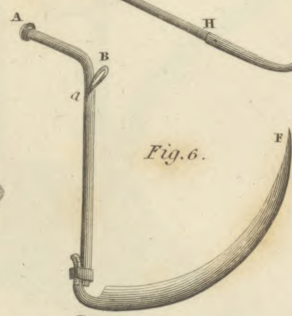



*Fig. 4.*

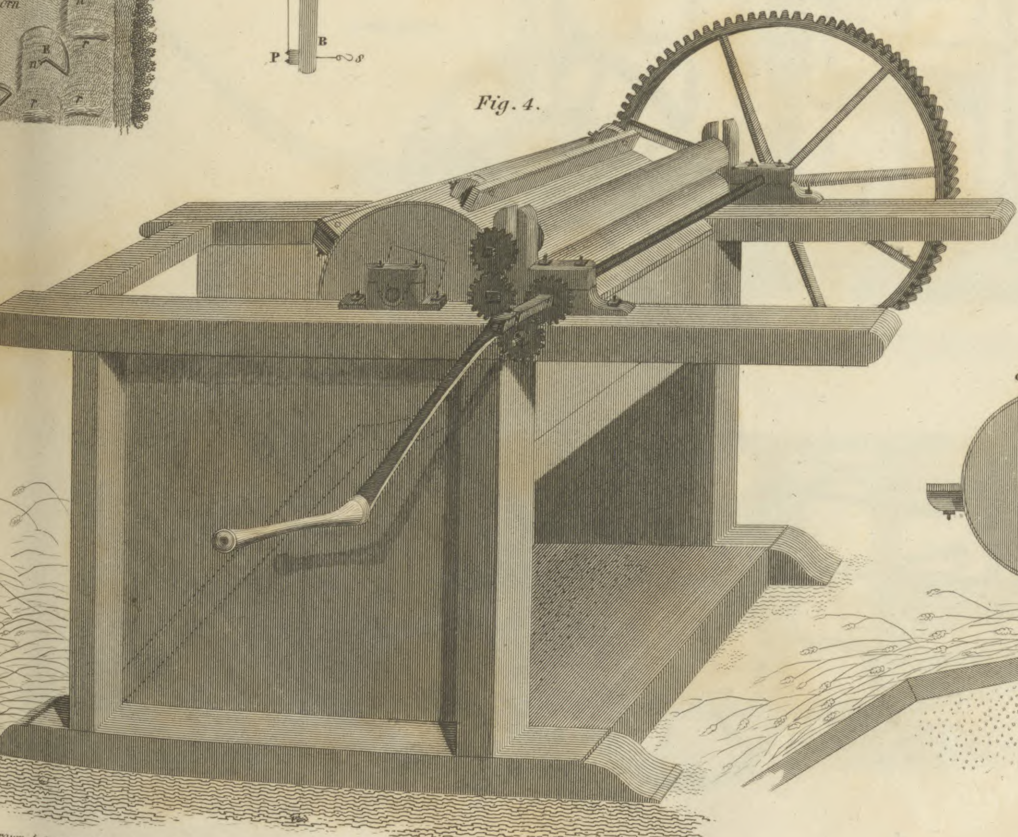
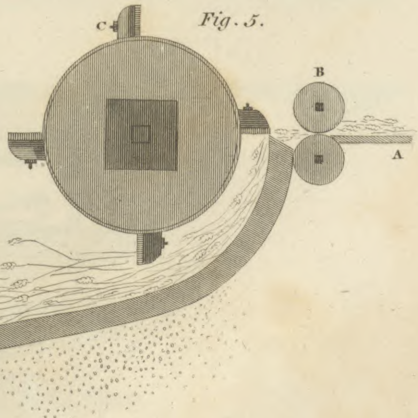


*Fig. 5.*

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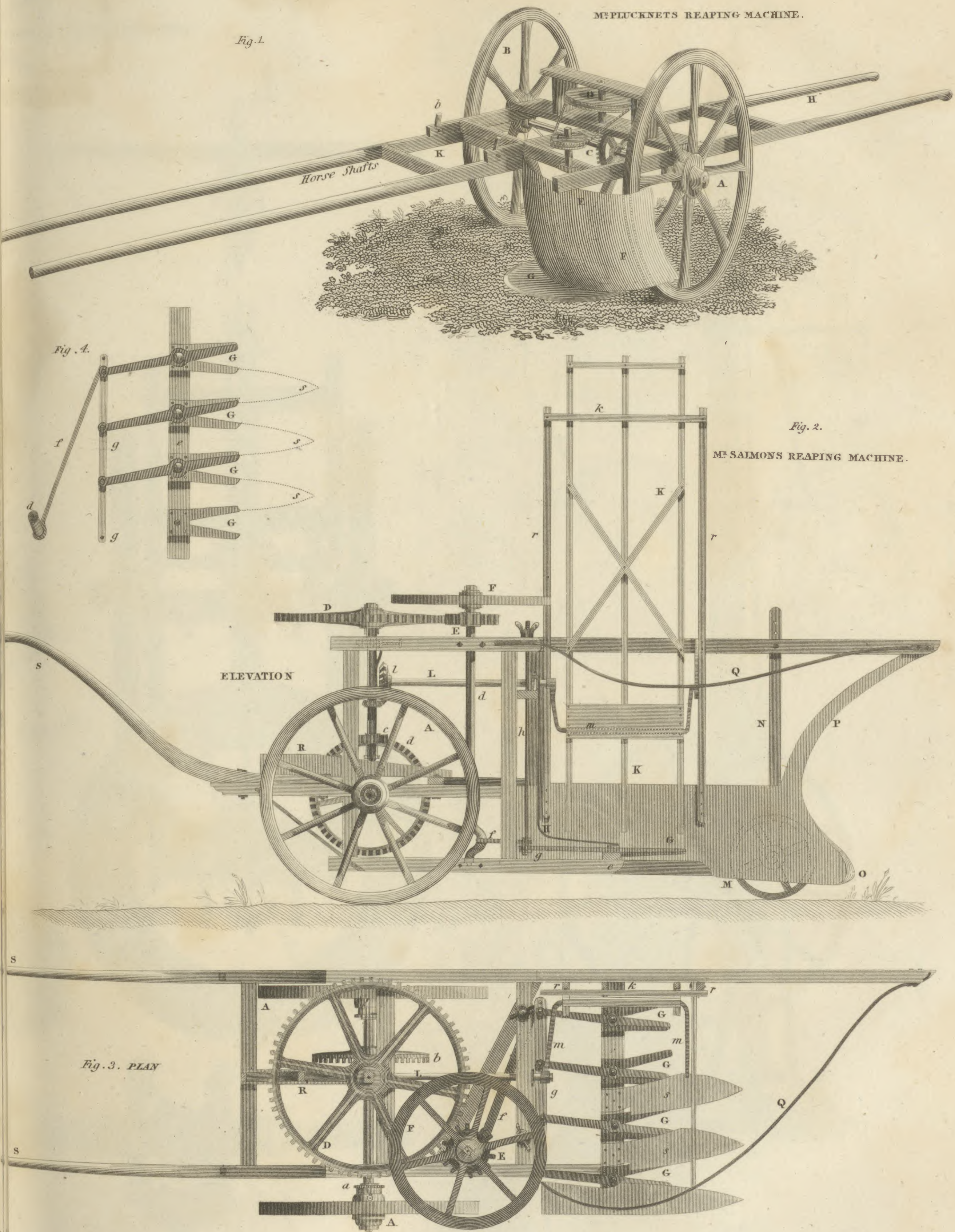


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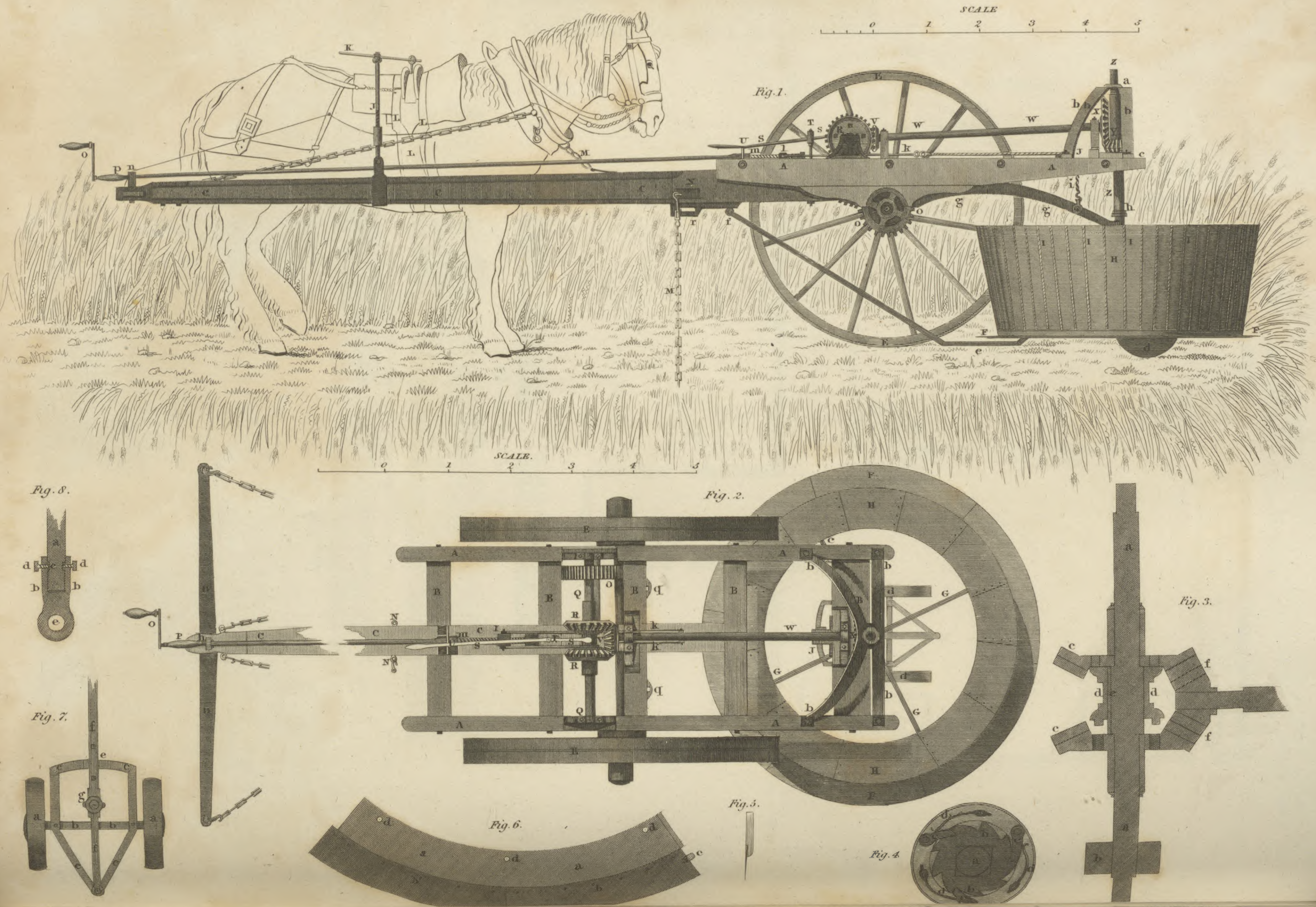
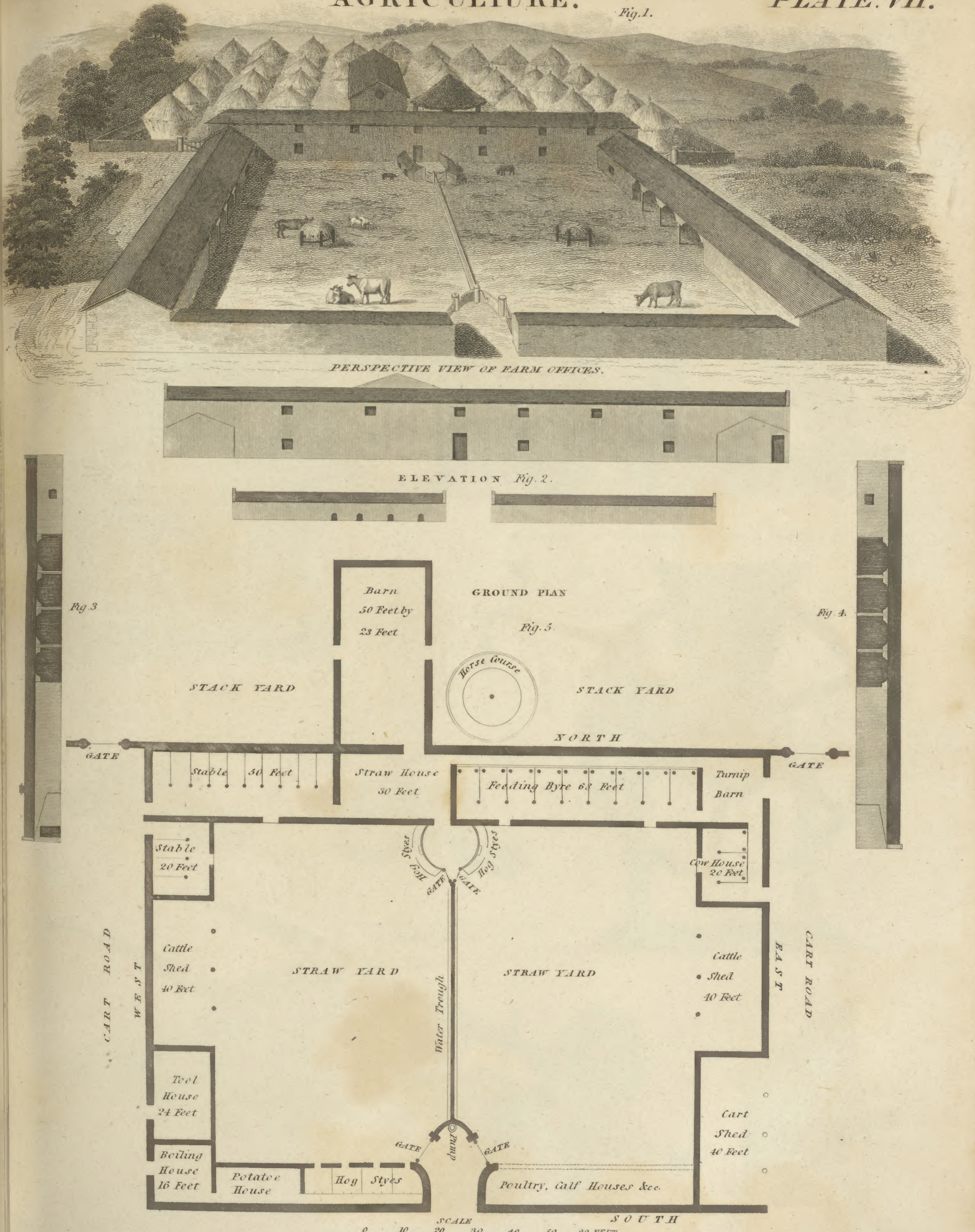
## AGRICULTURE

PLATE. VI.

Mr. SMITHS REAPING MACHINE



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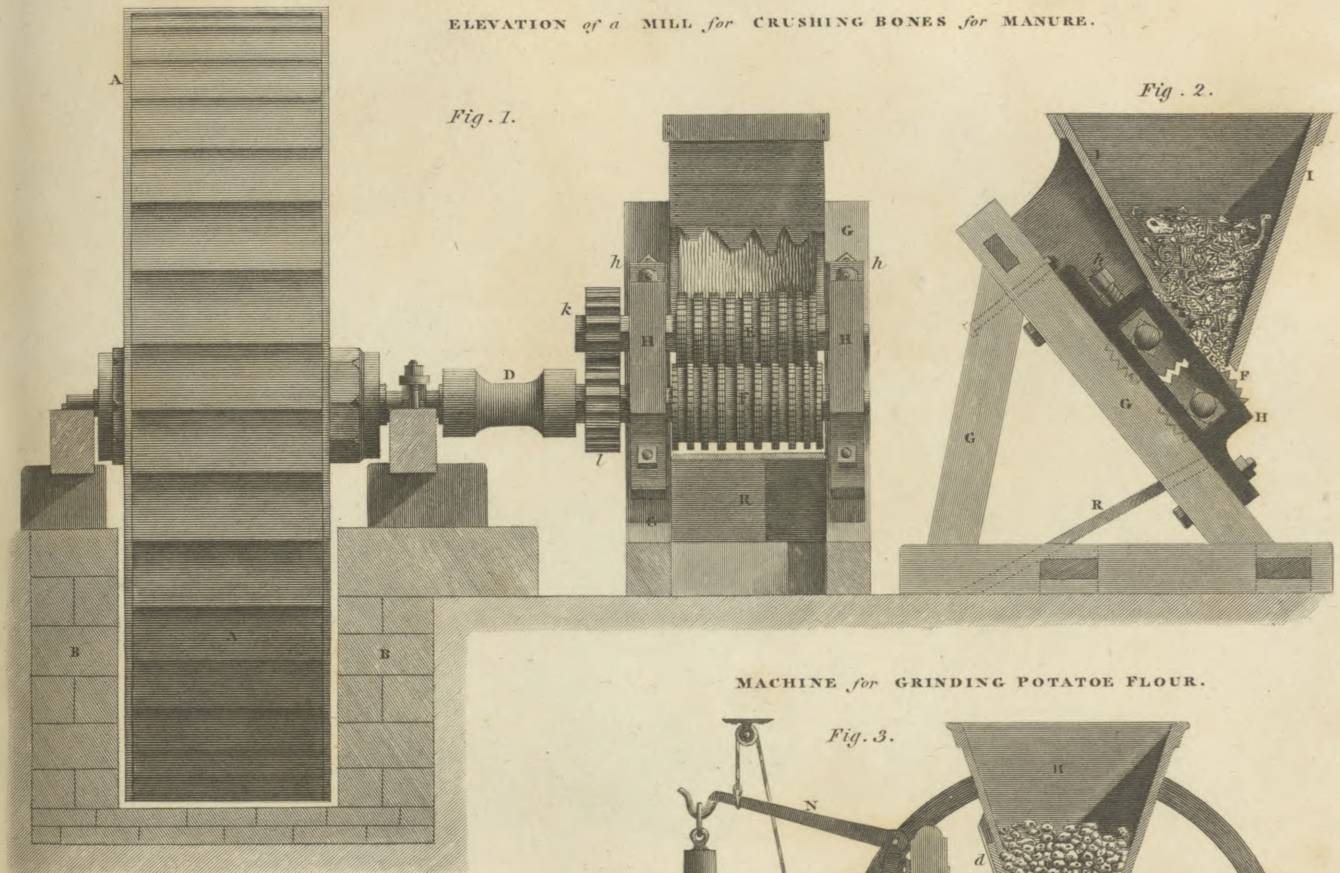
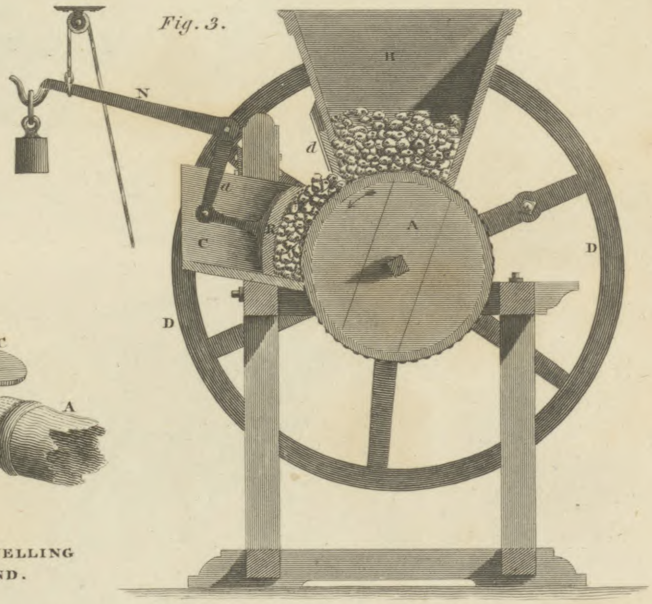
ELEVATION of a MILL for CRUSHING BONES for MANURE.

Fig. 1. Fig. 2.



MACHINE for GRINDING POTATOE FLOUR.

Fig. 3.



POTATOE SCOOP.

Fig. 5.

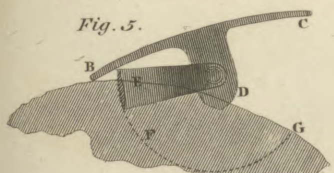
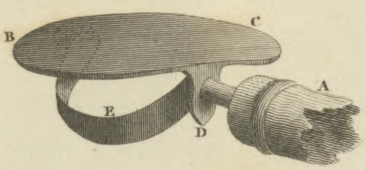


Fig. 4.



MACHINE for LEVELLING UNEVEN LAND.

Fig. 6.

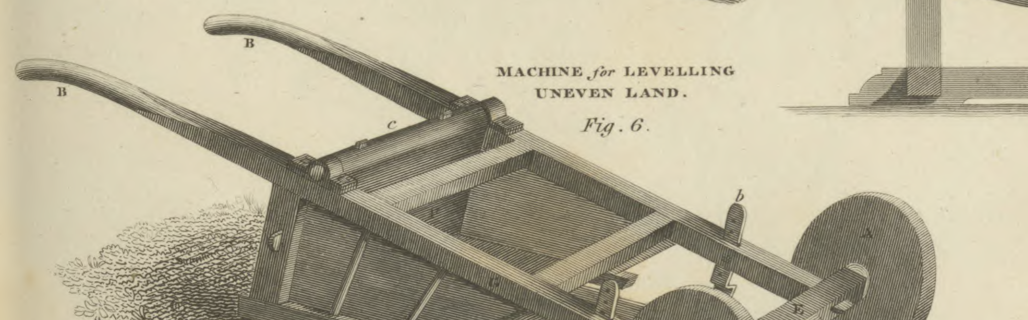
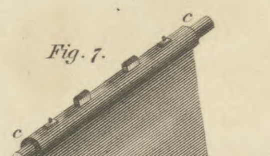


Fig. 7.



Farey Delt. Engraved by W. & D. Lizars Edinburgh.

Published by A. Constable & Co 1815.

Improved Black Cart Horse.

Suffolk Punch

Berrenger Pinx^t Milton Sculp^t

Published by A. Constable & Co. 1816.

PLATE X.

Ayrshire Cow.

Cheviot Ram.

Highland Poney.

Clydesdale Horse.

Published by A. Constable & Co 1815.

Thos Landseer Sculp

AGRICULTURE.

PLATE XI.

Long Horned Bull.

Berrenger Pinx.t

Short Horned Bull.

J. Howe Pinx.t

A. Wilson Sculp.t

Published by A. Constable & C.o 1815.

Galloway Bull.

Black faced Ram.

Argyleshire Bull.

T. Howe pinx. Published by A. Constable & Co 1815. Thos Landseer sculp.

Dishley.

Berrenger Pinx.t

Ryeland

Published by A. Constable & Co 1815.

South Down.

Milton Sculp.t

Merino Ram.

Merino Ewe.

Berenger Pinx.t Milton Sculp.t

Published by A. Constable & Co. 1815.

D'Aguesseau.

to impress this doctrine upon the minds of the younger members of the bar. Such, in particular, was the object of his discourse, pronounced in 1695, *Sur l'Union de la Philosophie et de l'Eloquence.* The same subject is treated at greater length, and in a more systematic and preceptive manner, in a treatise, written at a later period, under the title of *Instructions sur l'Etude et les Exercices qui peuvent preparer aux Fonctions d'Avocat du Roi.* These pieces (*Œuvres*, Tom. I.) are written in a clear, manly, and harmonious style, and are well worthy the attention of the general scholar, for their critical strictures on those authors whom he recommends to the students of law.

In the year 1700 he was appointed *Procurator-general*;—an office of higher dignity, and imposing more various and extensive duties, than that of advocate-general. He filled this office for seventeen years with the most splendid reputation; adding, by his lenity in criminal cases, and by his care of the public hospitals, the praise of humanity and benevolence to his other claims to the admiration of his countrymen. The political philosopher of the present day will probably, however, be inclined to question the justness of the encomiums bestowed upon his exertions during the severe scarcity of 1709; on which occasion, he appears to have instituted the most rigorous proceedings against those who were held up as enemies of their country and of mankind, under the names of forestallers and monopolists. But, in alluding to this part of his conduct, it may be proper to mention, that his opposition, at an after period, to the delusive projects of the famous John Law, and his elaborate treatise upon the subject of *Money*, (*Œuvres*, Tom. X.) afford undeniable proofs of the soundness of his views, in regard to some of the most important principles of political economy.

It had been early predicted of D'Aguesseau, that he would one day fill the place of Chancellor; and this prediction was at length realized in 1717, upon the death of Voisin, who then held the seals. Though he was yet little more than forty-eight years of age, his nomination to this high dignity gave general satisfaction; and was, indeed, intended as a popular measure by the Duke of Orleans, who had lately assumed the regency. His brother Valjouan, a man of abilities, but slothful and a humourist, was the only person who spoke with indifference on the occasion. "Rather you than I, brother," was his only remark when the new Chancellor hastened to him to announce his appointment. In fact, D'Aguesseau was soon made to experience the storms attendant upon this lofty station; for he had not been installed above a year, when he was deprived of the seals, and exiled to his estate. His steady opposition to the extravagant projects of Law, with which the regent and his ministers were wholly intoxicated, was the honourable cause of this first reverse of his fortune. In 1720, when the ruinous consequences of these schemes had filled the nation with distress and alarm, the chancellor was recalled from banishment; and he contributed not a little, by the firmness and sagacity of his counsels, to calm the public murmurs, and repair the mischiefs which had been committed.

Law himself had acted as the messenger of his recall; and it is said, that D'Aguesseau's consent to re-accept the seals from the hand of this adventurer, was much blamed by the literary corps, with which he had hitherto stood in high favour, as well as by the parliament. But his reputation appears to have sustained a much severer shock, when he endeavoured to prevail with the latter body, to register the declaration of the late king in favour of the famous bull *Unigenitus*;—a measure which they held in great abhorrence, and which he had himself firmly opposed during the life of Lewis. The regent's favourite Dubois, then Archbishop of Cambray, had moved his master to insist upon this act of registration, in the hope that he might thereby obtain for himself a Cardinal's hat; and it seems to have been thought, that the Chancellor had yielded his better opinion in compliance with the wishes of this worthless minion. Be this as it may, it is certain that he opposed the favourite with firmness, when he attempted, after being made prime minister, to take precedence in the council; and he was in consequence, in 1722, sent a second time into exile.

He now passed five years on his estate at Fresnes; and he always spoke with delight of this tranquil period, when he was left free from the cares of professional duty, and the distractions of public life, to cultivate his mind. The Scriptures, which he read and compared in various languages, and the laws of his own and other countries, formed the subjects of his more serious studies; the rest of his time was devoted to philosophy and literature, and the improvement of his park, where he was sometimes to be seen employed with a spade.

From these noble and congenial occupations he was again recalled, by the advice of Cardinal Fleury, in 1727; but the seals were not restored to him till ten years thereafter. During the intervening period, he had endeavoured to mediate in the new disputes which had arisen between the court and the parliament; but his interference seems to have given satisfaction to neither party; the one reproaching him with desertion from their cause, and the other with too great a leaning towards it. When the seals were at last restored to him, he completely withdrew from all affairs of state, and devoted himself entirely to his duties as Chancellor, and to the introduction of those reforms which had long occupied his inquiries and meditations.

Besides some important enactments regarding Testaments, Successions, and Donations, he introduced various regulations for improving the forms of procedure,—for ascertaining the limits of Jurisdictions,—and for effecting a greater uniformity in the execution of the laws throughout the several provinces. These reforms constitute a sort of epoch in the history of the jurisprudence of France, and have associated his name with those illustrious benefactors of her Civil Code,—L'Hopital and Lamoignon. The Duke de Saint-Simon however, alleges, that the Chancellor's reforms did not go so far as they would have gone, had he had less affection for his own order. He once, says this writer, confessed to a nobleman who spoke to him upon the propriety of cutting off certain lucrative abuses, that he could not bring his mind to a step which would so grievously diminish the profits of the law.

D'Agues-seau.

In 1750, when upwards of eighty-two years of age, he besought the king to accept his resignation; and he was accordingly permitted to retire, the king continuing to him the honours of his office as a special mark of his approbation. He died in the following year; and was interred, according to his own request, in the common burial-place of the village of Auteuil, where the remains of his wife, who died there in 1735, had been deposited. The name of this lady, whom he married in 1694, and by whom he had several children, was Anne Le Fevre d'Ormesson.

This great man has not, in all respects, been equally praised by those, who have, in their writings, transmitted his character to posterity. Saint-Simon and others reproach him with a degree of tardiness and indecision in his judgments, which sometimes greatly obstructed the course of justice. His own answer to this charge has been recorded by Duclos, and is worthy of notice: "When I recollect," said he, "that the decree of a Chancellor is a law, I think myself warranted in taking a long time for consideration." Saint-Simon and D'Argenson also impute to him some defects as a statesman; but his elevation of mind and extensive knowledge, his piety, probity, and disinterestedness, have been universally admitted and extolled. In his magisterial capacity, he was grave and dignified, without any approach to haughtiness; in private society, his manners were mild, equal, and even playful. He was particularly remarkable for the tenaciousness of his memory, and for the facility with which he could direct his attention to the most diversified exercises of intellect or imagination. At eighty years of age, he has been heard to repeat whole poems, which he had never perused since the days of his early youth; and when fatigued with professional duties, he could turn with equal alacrity to Euclid or to Racine. In summing up his character, all must agree with La Harpe, that he was "a man who did honour to France, to the magistracy, and to letters, by his virtues, his talents, his profound and various learning, and his enlightened views in the science of jurisprudence." (*Cours de Litterature*, Tom. XIV. c. 1.)

His published writings form a collection of thirteen volumes quarto; of which the first volume was published at Paris in 1759, and the last in 1789. The far greater part of these volumes relate to matters connected with his professional character and studies; but they also contain a variety of pieces upon miscellaneous subjects. We have already mentioned his discourses on the studies befitting the students of law, and his treatise on Money; and besides these, and some theological pieces, there is a Life of his Father, interesting from the view which it affords of his own early education under that excellent person; together with "Metaphysical Meditations," written in vindication of the grand truth, that, independently of all revelation, and all positive law, there is that in the constitution of the human mind which renders *man a law to himself.*

See *Histoire des Hommes Illustres de Regnes de Louis* XIV. *et de Louis* XV. par le Duc de Saint-Simon. *Memoirs Secretes,* par Duclos. *Les Loisirs d'un Ministre d'Etat,* par D'Argenson. *Eloge de D'Aguesseau,* par Thomas.

Air || Albania.

AIR. We had intended to exhibit, in a collected view, the various properties, physical and chemical, of this important elastic fluid; and also to have given the results of some original researches on its relations to heat; but as our experimental inquiries, undertaken with this view, are not yet completed, we shall refer the whole to a more comprehensive article. See ATMOSPHERE.

ALBANIA, a country of considerable extent, which, though in fact nearly independent, forms nominally one of the provinces of the Turkish empire. It extends from the thirty-ninth to the forty-third degree of north latitude, for the space of about 250 miles, along the Mediterranean and the Gulf of Venice. The extent inland nowhere exceeds one hundred miles; and is, in the southern part, not more than thirty. The chain of Pindus, called now the mountains of Sagori, of Metzovo, and of Suli, separate it, by an ill defined line, from Macedonia and Thessaly. The Turks divided it into Pashalics; of which the principal are those of Scutari, Ochrida, Vallona, and Butrinto; but these distinctions, in its present state of independence, are in a great measure obliterated. The divisions chiefly recognized are those formed by the varieties of the native tribes. Major Leake, who is allowed to be the best informed traveller on this head, divides them into the Ngege, or Ghegides, whose principal towns are Dulcigno, Scutari, and Durazzo; the Toske, or Toskides, who occupy Berat and Elbasan; the Liape, a poor and predatory race, who inhabit the mountains between the Toske and Delvino; and the Tsami, who inhabit the most southerly district, and whose principal towns are Suli and Paramithia. There are, besides, a great number of smaller divisions, too tedious to enumerate. (Leake's *Researches in Greece.*)

Albania nearly coincides with the country known to the ancients, under the name of Epirus. This country was then, as now, distinguished by the rude valour of its inhabitants. Its remote situation, and the want of union among its tribes, generally prevented it from acting any conspicuous part in Grecian politics. The only remarkable exception occurs in the reign of Pyrrhus II., who was justly ranked with the greatest captains of antiquity. After his death, the country was again split into a number of petty states, which were unable to resist the united strength of Macedon; and to that kingdom, Epirus continued subject, till both were alike subdued by the Roman arms.

It was during the time of the Greek empire, that the name of Albania was first given to this district. During the decline of the empire, the Albanians gradually rose to distinction, and at last to independence. Their valour enabled them to maintain their ground against the Bulgarians, who had occupied all the neighbouring districts of Greece. Nor were they less successful against the Turks, a more formidable enemy. Under the command of the celebrated George Castriot, commonly called Scanderbeg, they baffled all the efforts of Mahomet II. the conqueror of Constantinople. That powerful monarch entered Albania only to experience a succession of defeats, and was at length compelled to acknowledge its independence by a formal treaty. On the death

of Scanderberg, the Turks redoubled their efforts against Albania, which was at length reduced to a state of nominal subjection. The siege of Scutari, in 1478, formed the termination of this memorable struggle. The subjection, however, was always imperfect; revolts were frequent, and the inhabitants of the mountainous districts still preserved their independence. It was by the motives of pay and plunder, rather than by compulsion, that these hardy soldiers were allured into the Turkish ranks. In proportion as the Ottoman empire declined in vigour, its hold of Albania became less and less firm; and the vigorous and enterprizing genius of Ali Pasha, has now again converted this dependency into what may almost be called a separate kingdom.

Ali was born at Tepellene, a small town in the interior of Albania. His father held the rank of a Pasha of two tails, but was not possessed of any extensive power; and he died when Ali was only fifteen. In a district so turbulent, and filled with warlike and hostile leaders, the young chief was necessarily placed in a very critical situation. He is himself accustomed to boast, that he began his fortune with sixty paras and a musket; and an Albanian who attended a late traveller (Mr Hobhouse) declared, that he remembered to have seen Ali with his jacket out at elbows. Ali was ere long driven from Tepellene, his native place, and was abandoned by almost every follower. A plan was next formed for his destruction, by the inhabitants of Gardiki, a neighbouring town; and for this purpose, they surrounded, in the night time, a village where he had taken refuge. Ali escaped through a garden, but his mother and sister fell into the hands of the Gardikiotes, and were treated with every species of indignity; wrongs for which he afterwards took a dreadful vengeance. His address and activity enabled him gradually to repair his fortunes. He insinuated himself into the favour of Coul Pasha, then the principal chief of Albania, whose daughter he at length married. Having thus been enabled to collect some followers, he succeeded in surprising his present capital, Joannina, and in prevailing upon the Porte to recognize him as Pacha of that important district. From this time, he took the lead among the Albanian chiefs; employing sometimes force, sometimes money, and sometimes treachery, to increase his authority, and add to the extent of his dominions.

The most formidable adversaries with whom Ali had to contend, were the Suliotes, a people placed in the southern extremity of Albania. They inhabit an almost inaccessible range of mountains, beneath whose gloomy shade winds a river, which Dr Holland conjectures, on very plausible grounds, to be the Acheron of the ancients. (*Travels in the Ionian Isles and Albania.*) The strength of their native bulwarks, their passion for war, and contempt of death, made them the terror of Albania, which they frequently invaded; while no foreign power had ever ventured to scale the tremendous barriers by which they were guarded. Ali at length succeeded, partly by force, and partly by bribery, in gaining the passes which led into their country; and the whole nation, after a furious resistance, was reduced to subjection, and partly extirpated.

In 1811 and 1812, Ali attacked and defeated the Pashas of Berat and Delvino; by which means he gained possession of some of the finest parts of Albania, and a population of between 200,000 and 300,000 souls. Tepellene, his native place, now fell into his power; and now also it was, that he obtained the means of inflicting signal vengeance on Gardiki. With his accustomed duplicity, he pretended a complete oblivion of all grounds of resentment, until he had surrounded and enclosed the city with his troops; when upwards of 700 of those of the inhabitants who were supposed to have been most deeply involved in the ancient guilt, were dragged into a large khan near the city, and bound together with cords. On a signal given by Ali, the Albanian soldiery, who were stationed on the walls of the khan, began a discharge of musketry, which continued until the destruction of the whole 700 was completed.

It seems impossible to define with perfect precision, either the extent of Ali's dominions, or the degree of authority which he possesses. Even within Albania, the Pachalic of Scutari remains still independent. The tract over which he bears sway, is bounded on the north by an irregular line, extending from Durazzo to the Gulf of Salonica. It comprehends the mountainous district of Macedonia, nearly the whole of Thessaly, and great part of Livadia. On the eastern side, he is kept in check by Ismael Bey, who possesses an authority nearly as independent over the plains of Macedonia. In Albania, his power is almost absolute; and while little regard is paid to the imperial firman, a letter with the signature of Ali commands implicit obedience. The Albanians are enthusiastically attached to him; they view him as a native sovereign; they admire the energy of his character, and when they hear of any other chief, commonly remark, that "he has not a head like Ali."

In the relations between Ali and the court of Constantinople, mutual fear has hitherto preserved an outward good understanding. The progress of this enterprizing chief has been long viewed with jealousy and alarm; but the Porte was never in a condition to hazard driving him into open rebellion. It has been found prudent, therefore, to invest him, by its firman, with the government of those provinces which the sword had already placed in his possession. Ali, on the other hand, pays an outward deference to the Porte; and remits to it some portion of the revenue which he collects. He has also uniformly supported that power with nearly his whole force, against the foreign enemies with which it has had to contend. He even marched against Paswan Oglou, and was present at the siege of Widdin; and his son Mouctar Pasha, distinguished himself greatly in the late war against the Russians. In all other respects, whether as to the internal government of Albania, or its foreign relations, he acts completely as an independent monarch. The Porte has omitted no means of inducing him to repair to Constantinople, and has even proffered to him the dignity of grand Vizier; but Ali has uniformly resisted every such invitation, well knowing that his arrival at that capital would be the immediate signal for striking off his head. Buonaparte is also

believed to have courted his favour, and to have offered him the dignity of King of Albania; but the Pasha always viewed the ambitious designs of that conqueror with alarm, and attached himself to England; with the politics and interests of which country, it appears from his conversations with Dr Holland, he was tolerably well acquainted.

The natives estimate Ali's military force so high as fifty, sixty, or even 100,000 men. This could only apply to the case of a general levy *en masse*, in the event of invasion. It does not appear that Ali has ever brought into the field a greater disposeable force than 15,000. His standing army is supposed to be about 10,000, of whom 4,000 or 5,000 are stationed round his capital Joannina. The amount of his revenues is still more uncertain. They arise from the following sources: 1. A land tax, amounting generally to about 10 *per cent* of the produce. 2. A tax on cities and towns, levied in the form of requisition. 3. The customs, which he has raised to six *per cent*. 4. The inheritance of all who die without male heirs. There are several minor sources; and besides his public revenue, Ali is supposed to possess private property to the amount of 4,000,000 piastres, or L. 200,000 *per annum*. It seems impossible to conjecture, either what may be the amount of his entire revenue, or what proportion he remits to Constantinople; but it is generally believed, that the treasure which he has accumulated is very considerable.

Ali is now (1815) sixty or sixty-one years of age; his figure is corpulent and unwieldy, his neck short, his stature about five feet nine inches. The expression of his countenance is striking and majestic; and his features give no indications of those terrible qualities by which he is characterized. His abilities are certainly of no mean order. He displays that union of deep thought and contrivance, with prompt and decisive action, which indicates a mind equally formed for politics and for war. He is remarkable for his address, both in gaining friends, and in lulling asleep the suspicions of his bitterest enemies. But, if his abilities are of a superior order, his dispositions are of a kind which render him an object of fear and detestation. His cruelty rather resembles that of an Indian savage, than of even the least civilized European. Impaling, and roasting alive, are among the common punishments reserved for those who have unhappily offended him. The fierceness of his cruelty is only exceeded by the depth of his dissimulation. It is impossible for the most skilful observer to conjecture, from his outward deportment, the real sentiments with which he regards any individual. The only observable difference, consists in a peculiar kindness of manner, towards those unfortunates, whose cruel doom he has silently and unrelentingly sealed.

Ali's ordinary residence is near Joannina, in an immense building, which combines the characters of a palace and a fortress. The outer courts are irregularly crowded with Albanian soldiers, and with persons of all descriptions, who attend upon, or have petitions to present to him. Each petitioner, in approaching, kneels and kisses his garment. He exercises in person the whole judicial authority; and his decisions, though necessarily given too promptly, are however said to be guided by an apparent wish of arriving at the truth, and of doing justice. It may be supposed that this employment, joined to a minute attention to every other part of his administration, must fully occupy his time. Accordingly, he rises at six in the morning, and with the exception of an hour at dinner, and an hour at supper, spends the whole day in business. His habits at table are extremely temperate, though he is not so strict a Musulman as to decline the use of wine. His haram contains three hundred females of various descriptions. It forms an edifice entirely distinct from the rest of the seraglio, and is said to be furnished in a style of the most gorgeous magnificence; but no European has hitherto found admission into it.



Although the government of Ali is completely despotical, yet, viewed comparatively, it appears to be better for Albania, than the terrible anarchy to which it was formerly exposed. He has freed that country from a race of petty tyrants, and from perpetual scenes of internal warfare. His vigorous administration has nearly extirpated those numerous predatory hordes, who found shelter in the mountainous districts, and spread terror and desolation over the plains.

The inhabitants of Albania are estimated at twelve hundred thousand; those of Ali's whole dominions at two millions. Albania contains a considerable proportion of Turks and Greeks; but the basis of the population, and that in which Ali places his chief confidence, consists of its original race. This remarkable people differ completely from every other included within the limits of the Turkish empire. Their conversion to Mahometan tenets has been very imperfect, and chiefly induced by political motives. In every family the males usually go to the mosque, the females to church; and some members of a family are seen in the most amicable manner eating from the same table, and even from the same plate, meats forbidden to the others. With the Turks, accordingly, infidel and Albanian are terms nearly synonymous. Ali himself, does not appear to make religion a ground of any the slightest distinction between the different classes of his subjects.

The native Albanian is of a middle stature; his face is oval, with high cheek bones; his neck long, his chest full and broad. His air is erect and majestic, to a degree which never fails to surprise the traveller. He holds in utter contempt that dissimulation which is characteristic of the Greek, and piques himself upon giving utterance to every sentiment without the smallest reserve. Equally remote from the grave and sluggish deportment of the Turk, he is gay, lively, and active. Averse, however, to regular industry, his whole delight is in arms and plunder. He goes constantly armed; and there are few Albanians who, in the prime of their life, have not belonged to some of the numerous bands of robbers, who infest the mountains of their native country, of Thessaly, and of Macedonia. This profession carries with it no disgrace; it is common for the Albanian to mention circumstances which occurred, "when he was a robber." In proportion as the trade of robbing becomes overstocked, part of those engaged in it seek employment in the service of the Sultan, and of the different Pashas throughout the Turkish empire; by

all of whom the Albanians are regarded as the most valuable of their troops.

An Albanian military force, according to the description of Dr Holland, cannot so properly be called an army, as a tumultuous assemblage of armed men. There is no regular distribution into corps; nor is much regard paid to the authority of any officer, with the single exception of the Pasha himself. Yet, such is their activity and intrepidity, that they have sometimes proved formidable to the best disciplined European armies. Whatever was done in the last Turkish campaign against the Russians, is said to have been achieved by Albanian troops.

This fierce and haughty race display a greater degree of contempt for the female sex, than is usual even among the most barbarous nations. The females are literally regarded as inferior animals, and treated as such; but, in the country districts, they are not confined, or veiled, as is customary in Mahometan countries.

The dress of the Albanian consists of a cotton shirt, a jacket, a mantle, sandals, and a red cap; to which is added, a large *capote*, or great coat, as a shelter from the weather. Every part, except the shirt, consists of woollen. As they have usually only one suit, which they wear day and night, it soon becomes a dreadful assemblage of dirt and vermin; and at length literally falls to pieces. The dress of the females is more various, and often fantastical. A singular custom prevails among the girls, of stringing together the pieces of money which they have collected for their portion, and wearing them upon their heads. Some of them have their hair hanging down in braids to a great length, loaded with this species of ornament.

Joannina, the present capital, is beautifully situated on the banks of a small lake, enclosed within a circuit of lofty mountains. The houses, in general, are not externally either splendid or elegant; and they are built in the most irregular manner, with scarcely any approach to the form of streets. The intermixture however of gardens and trees, gives to the city a fine appearance from a distance; particularly when combined with the magnificent back-ground, which everywhere crowns the landscape. There is a considerable number of Greeks at Joannina, who display an active and intelligent character, and cultivate with ardour the different branches of science and literature. The total number of inhabitants is estimated at upwards of thirty-five thousand.

The commerce of Albania is chiefly carried on through Arta, a small city situated on a gulf of the same name, in the most southern district of the country. The principal merchants however, are Greeks residing at Joannina, among whom a very active commercial spirit appears to prevail. Ali, who anxiously endeavours to promote the trade of his dominions, without however knowing the right way, imposes great restraints on the removal of the merchants. He generally insists, that at least one member of a family should continue to reside at Joannina. The mercantile houses of this city have often branches in other countries, particularly Germany and Russia, and several of them suffered considerably by the conflagration of Moscow. Under the continental system of the late French ruler, Malta became the great channel for the trade of Albania, and, notwithstanding the recent political changes, may probably retain it to a certain extent. The exports consist almost entirely of unmanufactured produce. Notwithstanding its mountainous character, the fertility of its plains affords a surplus of grain, of which, upwards of fifty cargoes are sent to Italy, the Ionian isles, Malta, and other places. The Pasha, however has checked this commerce by the impolitic system of assuming the monopoly of it into his own hands. Wool is exported, chiefly unmanufactured; but partly also wrought into coarse cloth. Other important articles of export are oil, tobacco of good quality, cotton and cotton yarn, chiefly from Thessaly. Some cargoes of wood for building and fire, are annually sent to Malta. The chief imports consist of woollen cloths, used for winter coverings. For this purpose, the preference is given to a coarser and cheaper species than any that is usually manufactured in Great Britain. This is supplied from Germany. Albania imports also guns, gunpowder, hardware, coffee, and sugar. On the 8th of October, an annual fair is opened in the neighhourhood of Joannina, and continues for fourteen days, when the imported articles are exchanged for native commodities, which then pour in from every quarter.

The reader will find much interesting information in regard to this country, and its present ruler, in the lately published *Travels* of Mr Hobhouse, and of Dr Holland. The latter resided for some time at Ali's court, where, in quality of physician, he enjoyed the privilege of a familiar intercourse with that extraordinary personage; and the anecdotes which he relates, give no small share of interest to his otherwise valuable and instructive publication. (B.)

ALCARRAZAS, a name, of Arabic origin, applied to a kind of porous earthen ware, much used in Spain for cooling water. See COOLING.

ALCOOMETER, or ALKOOMETER, a name given by Richter to the Hydrometer with a graduated stalk. See ARÆOMETER.

ALEUTIAN, ALEUTIC, or ALEUTSKY ISLANDS, (so called from the Russian word *aleut*, signifying a bold rock), is the name given by the Russian discoverers to a chain of small islands, situated in the Northern Pacific Ocean, and extending in an easterly direction, from the peninsula of Kamtschatka, in Asiatic Russia, to the promontory of Alaska, in North America. These islands are very shortly noticed in the body of the work under the head *Fox Islands*. According to the practice of the most recent Russian geographers, we have comprehended the whole of this archipelago under one general name, although it has been sometimes divided into three several groups: those nearest to the eastern coast of Kamtschatka being properly called *Aleutian*; the central group the *Andreanofskie*, or *Andrenovian*; and those nearest to the American promontory, the *Fox Islands*. The Russian geographers usually separate Behring's and Copper Island, which are at the western extremity of this chain, from the other parts of it, included by them under the general name of

Aleutian Islands.

Aleutian Islands; * but as there seems no good reason for this exception, it certainly would be better to comprehend the whole under one general denomination.

Progress of Discovery.

The first voyage of discovery in this remote and dangerous archipelago was projected by Peter the Great, whose enterprising mind appears to have been strongly excited by the question, then much agitated, relative to the distance between the Asiatic and American Continents; the solution of which seemed to be facilitated by the recent conquest of Kamtschatka. A short time previous to the death of that monarch, which took place in 1725, he drew up instructions, with his own hand, for the conduct of an expedition, which was to be entrusted to the command of an officer named Behring, who had already made several voyages in the sea of Kamtschatka, by order of the Crown. In 1728, Behring set sail from the mouth of the Kamtschatka river, and coasted the eastern shores of Siberia, as far to the northward as latitude 67° 18′, but made no discovery of the opposite Continent. In 1729, he again set sail, for the purpose of prosecuting the same enterprise, but with no better success. A third voyage was undertaken, by order of the Empress Anna, in 1741; and Behring was again selected as chief of the expedition; another vessel being entrusted to the command of Tschirikoff. This enterprise proved more fortunate, and led the way to all the subsequent important discoveries of the Russians in those seas; although the immediate results of the voyage, upon the whole, were not deemed commensurate with the time and expence employed in fitting out the expedition. The principal object of the undertaking, however, appears to have been accomplished. Tschirikoff discovered the coast of America in the 56th degree of latitude; and Behring, who was separated from his companion in a storm, saw it in latitude 58° 28′. On his voyage back to Kamtschatka, Behring's ship was driven on the island which now bears his name, where he soon afterwards died.

Behring's Voyages, 1728—1741

Voyages undertaken by private Adventurers.

The two uninhabited islands, Behring's and Copper Island, now became known to the natives of Kamtschatka, who frequently resorted thither, for the purpose of hunting sea-otters, and other animals, affording valuable furs, with which they carried on a lucrative traffic. Some of the vessels which sailed upon these expeditions were driven, by stormy weather, to the south-east, by which means the group of Aleutian Islands came to be discovered. These islands seem to have been first visited in the year 1745, and continued to be resorted to, for some time, by private individuals, without attracting the attention of the Russian Government. In the above-mentioned year a vessel, called the Eudokia, was fitted out at the expence of some private adventurers, and the command given to Michael Nevodtsikof, a native of Tobolsk. Having discovered three unknown islands, they ventured upon one of them, in order to kill sea-otters, of which they found a large quantity. These islands were undoubtedly the nearest Aleutian Islands, and were found well inhabited. The Russians continued upon this island until the 14th September 1746, when, having incurred the enmity of the natives by their arbitrary and hostile proceedings, they put to sea, with the view of looking out for some uninhabited islands. Being overtaken, however, by a violent storm, they were driven about until the 30th October, when their vessel was wrecked upon the rocky shore of the island of Karaga, the inhabitants of which were of the Koriac tribe, and tributary to the Russian empire.

Voyage of Michael Nevodtsikof. 1745.

From this period, the zeal or avarice of individual adventurers prompted them to undertake repeated voyages to the new-discovered islands, in some of which they penetrated as far eastward as the Fox Islands, where they collected a quantity of valuable skins; but, in consequence of their own rapacity and misconduct, they were frequently embroiled in fatal quarrels with the natives. One of the most remarkable of these voyages was that of the St Andrean and Natalia, fitted out by the merchant Andrean Tolstyk, which sailed from the mouth of the Kamtschatka river on the 27th September 1760, and on the 29th reached Behring's Island. Having been driven on shore by a violent autumnal storm, they were here obliged to pass the winter; and, after refitting, they put to sea again on the 24th June 1761. They passed by Copper Island, which lies about 150 versts from the former, and steered S. E. towards the Aleutian isles, which they did not reach before the 6th August. From thence they proceeded, on the 19th, in quest of some more distant islands, for the purpose of exacting tribute, steering their course N. E. and N. E. by E., and were driven, by a gale of wind, towards an island, where, on the 30th August, they anchored in a safe bay. This island they called Ayagh or Kayaka, and another, which lay at the distance of about 20 versts, Kanaga. The Russians persuaded the inhabitants of these islands to become tributary to the empress, to which they made no great objection. Four other islands were discovered in the neighbourhood; and the crew remained here, in great tranquillity, until the year 1764, but met with no great success in their hunting excursions. This group of islands, which lies somewhat to the north-west of the Fox Islands, was denominated, in honour of the vessel which made the discovery, the Andreanofskie, or Andrenovian Isles.

Voyage of the St Andrean and Natalia. 1760.

Discovery of the Andrenovian Islands.

Voyages to the Fox Islands.

From the year 1758 to 1760, several vessels visited the Fox Islands, and obtained considerable cargoes of sea-otter and fox skins. But the crews appear to have behaved with the most shameful inhumanity towards the natives; and little information was derived from these voyages, except a few particulars which

* Mr Pinkerton appears to be mistaken when he says, that, "the nearest Aleutian Isles of the Russians, are those which we term Behring's and Copper." (*Geog.* 3d. Edit. Vol. II. p. 423.) We do not find that the term *Aleutian*, has ever been applied to the two islands above mentioned. That name was first given, by the early Russian discoverers, to the small group of islands, situated to the S. E. of Behring's island; and the islands composing this group, were sometimes called the *nearest* Aleutian isles, to distinguish them from the more easterly and remote parts of the chain. See Coxe's *Russian Discoveries*, chap. ii.

Aleutian Islands.

transpired during the course of a judicial investigation into their conduct. In 1762, four vessels sailed for the Fox Islands, of which only one returned safe to Kamtschatka. The first was the Zacharias and Elizabeth, fitted out by Kulkof and Company of Vologda, under the command of Drusinin, with a crew of thirty-four Russians and three Kamtschadals. This vessel touched at the Aleutian Islands, and, in the beginning of September 1763, arrived at Umnak, one of the most considerable of the Fox Islands. On the 22d September they proceeded to Unalashka, where the vessel was brought into a safe harbour. Here the crew formed themselves into hunting parties, but were soon afterwards attacked separately by the natives, and cut off, with the exception of four individuals, who, after defending themselves with astonishing courage and intrepidity, and suffering incredible hardships, succeeded in making their escape from the island in a *baidar*, their own vessel having been destroyed by the savages. One of these four died during the home voyage; but the other three returned safe to Kamtschatka, and gave an account of their adventures.

1762. Voyage of the Zacharias and Elizabeth.

The second vessel which sailed from Kamtschatka in 1762 was the Trinity, fitted out by the trading company of Nikiphor Trapesnikof, a merchant of Irkutsk, under the command of Ivan Korovin, and manned with thirty-eight Russians and six Kamtschadals. In the month of October they cast anchor before the south side of Behring's Island, where they resolved to winter, on account of the late season of the year. On the 1st of August 1763, Korovin sailed from Behring's Island, in company with Dennis Medvedef, who commanded a vessel* fitted out by Jacob Protassof, merchant of Tiumen. On the 15th the former vessel made Unalashka, and Medvedef reached Umnak. After having reconnoitred the coast, and received hostages from the *Toigons*, or Chiefs, Korovin sent out several hunting parties; but the natives soon began to exhibit hostile intentions, and three Kamtschadals, belonging to Kulkof's ship, arrived with accounts of the destruction of that vessel, and the massacre of the crew. On the 10th December, the savages assembled in large bodies, and invested the hut which the Russians had constructed, and continually annoyed them with their darts. Korovin, finding himself thus harassed by the natives, ordered the hut to be destroyed, and retired to his vessel, which was removed to the distance of an hundred yards from the beach, where they lay at anchor from the 5th March to the 26th April 1764. Here the natives attempted to surprise the vessel; but Korovin, having been warned of their approach, compelled them to retreat. On the 26th April, Korovin sailed from Unalashka, and, after being driven about by contrary winds, the vessel was at length stranded, on the 28th, in a bay of the Island of Umnak. Having got on shore, the crew attempted to secure themselves between their *baidar* and some empty barrels, with the sails spread over them in the form of a tent. Next morning, before the break of day, they were surprised by a large body of the natives, who attacked them with their darts, and wounded every one of the crew. Korovin, however, sallied out, in company with four Russians, and put the savages to flight; although he and his party were so severely wounded, that they had scarcely sufficient strength to return to the tent. During the night, the vessel was dashed to pieces by the storm. On the 30th of April, they were again attacked by the natives, who, however, were soon put to flight by the fire of the Russians. On the 21st of July, Korovin, with the remainder of his crew, which was now reduced to the number of twelve persons, including six Kamtschadals, put to sea in a *baidar*; and, having landed upon another part of the same island, they discovered the remains of a vessel which had been burnt, and, at a small distance, a deserted Russian dwelling, containing twenty dead bodies in their clothes; among which they recognized several of those individuals who had sailed in Protassof's vessel, and distinguished, among the rest, the commander Medvedef. Korovin afterwards joined Glottof's vessel, (of whose proceedings we shall immediately give some account), which he quitted in the month of April 1765, and went over, with five other Russians, to Soloviof, with whom he returned, the following year, to Kamtschatka.

Voyage of Korovin in the Trinity.

The third voyage from Kamtschatka in 1762, and the most fortunate and most remarkable of the whole, was that of the Andrean and Natalia, which was fitted out by Terenty Tsebaeffskoi and Company, under the command of Stephen Glottof, an experienced and skilful seaman of Yarensk. This vessel sailed on the 1st October, with a crew of thirty-eight Russians and eight Kamtschadals. Having wintered at Copper Island, they set sail from thence on the 26th July 1763, and steered for the Fox Islands. In consequence of storms and contrary winds, they were thirty days on the voyage to Umnak, where they arrived on the 24th August, and, without dropping anchor, sailed farther in quest of new islands, of which they passed eight contiguous to each other, and separated by straits from 20 to 100 versts broad. Glottof, however, did not land until he reached the most eastward of these islands, called by the inhabitants Kadyak. Here, and in the neighbouring islands, they passed the winter, and collected a considerable quantity of furs; but as the conduct of the natives, at first decidedly hostile, was always suspicious, Glottof did not think it prudent to prolong his stay; and accordingly, having taken on board all the peltry and stores, he left Kadyak on the 24th May 1764, and sailed for Umnak, where he arrived on the 3d July. He remained here two years, sending out hunting parties through the islands of Umnak and Unalashka, and commenced his voyage homewards in the month of July 1766. In the month of August he arrived safe in Kamtschatka river with a rich cargo.

Voyage of Stephen Glottof, in the Andrean and Natalia.

Soloviof, to whose voyage we have already alluded, sailed from Kamtschatka on the 25th of Au-

Voyage of Soloviof in 1764.

* This was the fourth vessel which sailed in 1762; but, as the whole crew were massacred by the natives, we have no distinct account of the voyage.

Aleutian Islands.

gust 1764, in a ship called the Holy Apostles Peter and Paul, fitted out by Jacob Ulednikof and Company, merchants of Irkutsk. This vessel reached Unalashka on the 17th September, where Soloviof passed two winters; and having succeeded, notwithstanding the continual hostility of the natives, in collecting a considerable cargo of peltry, he returned to Kamtschatka in the month of July 1766.

Having thus traced an outline of the gradual progress of early discovery in this archipelago, it seems unnecessary to proceed with an enumeration of the subsequent voyages performed by private individuals. These were undertaken merely for commercial purposes; the accounts brought home by the adventurers were generally imperfect and incorrect; and rather tended to excite than to gratify the curiosity of those who might be desirous of obtaining more accurate and more ample information. We shall, therefore, now turn to the conduct of those expeditions, which were fitted out by the State for the express purpose of discovery.

Expedition of Capt. Krenitzin and Lieut. Levashef. 1768.

In the year 1768, Captain Krenitzin and Lieutenant Levashef sailed from the mouth of the Kamtschatka river, by order of the Empress Catharine, to examine the chain of Aleutian Islands. This commission they accordingly executed very carefully, having surveyed the whole of this archipelago, from Behring's Island to the promontory of Alaska; and, after spending the winter among the Fox Islands, they returned to Kamtschatka in the autumn of 1769.

Capt. Cook's last Voyage. 1778.

But our great navigator, Captain Cook, communicated more accurate scientific information respecting these islands, as well as the coasts of the two continents, than all the previous voyages of the Russian discoverers had afforded. During his third and last voyage, in the year 1778, he surveyed the eastern portion of this archipelago, accurately determined the positions of some of the most remarkable islands, and corrected many errors of former navigators.

Expedition under Capt. Billings. 1785.

In the year 1785, a fresh expedition was set on foot by the Russian government, the command of which was entrusted to Captain Billings, an English naval officer in the Russian service, who had accompanied Captain Cook in his last celebrated voyage to the Pacific Ocean. This expedition appears to have been suggested by Mr Coxe, who was at that time at St Petersburgh, and whose *Account of the Russian Discoveries between Asia and America*, had already attracted the attention of the Russian government. During this voyage, which was not completed until the year 1796, Captains Billings and Sarytschef explored the whole chain of the Aleutian islands, particularly that part of it which had been visited by Captain Cook, and some parts of the adjacent western coast of America. Ample details of the conduct of this expedition have been published in the narratives of Martin Sauer, who officiated as secretary to Captain Billings, and of Admiral Sarytschef.

Expedition from Cronstadt, to the north-west coast of America.

Some years after the termination of the expedition under Captain Billings, the attention of the Russian American Company was turned towards the best means of supplying their settlements on the north-west coast of America with provisions and stores of all kinds; and it was resolved to try whether the conveyance by sea would not answer the purpose better, than the long and tedious journey by land to Ochotsk. With the view of ascertaining the practicability of the project, Captain Krusenstern, an experienced Russian naval officer, who had served for a long period in the British Navy, suggested the plan of an expedition from Cronstadt, round Cape Horn, to the Aleutian Islands and the north-west coast of America. This plan was approved of by Count Romanzof, the Minister of Commerce, and Admiral Mordwinof, Minister of the Marine, and obtained the sanction of his Imperial Majesty. Two vessels, called by the Russians the Nadeshda and the Neva, were accordingly purchased in London for the voyage. The command of the expedition was intrusted to Captain Krusenstern, the original author of the plan; and Captain Lisiansky was appointed to the Neva. These two vessels accordingly sailed in company from Cronstadt, in the month of August 1803, and, after a short stay at Falmouth, proceeded to the Brazils; from whence they sailed round Cape Horn to the Sandwich Islands. Here they separated; the Nadeshda being ordered on a distinct mission to Japan and China; while Captain Lisiansky, in the Neva, proceeded to Kadyak and the American settlements. Of this voyage, very full and interesting accounts have been lately published by Captains Krusenstern and Lisiansky, and by Dr Langsdorff, who accompanied the expedition in the quality of physician.

Voyage of Captains Krusenstern and Lisiansky, 1803.

Enumeration and Description of the Aleutian Islands.

From the ample sources of information, to which we have alluded in the foregoing narrative, we shall now proceed to exhibit an enumeration and general description of the islands composing this singular chain, which appears to be a prolongation of either continent. We shall begin with the more westerly part of the chain, consisting of those islands which lie nearest to Kamtschatka, and proceed eastwards to the American promontory. The first is Commodore's or Behring's Island, situate (according to Cook's reckoning), in 55° of latitude, and 6° of longitude from the harbour of Petropaulowska in the bay of Awatska. It is from 70 to 80 versts long, and stretches from north-west to south-east. Ten leagues from the south-east point of this island, in the direction of east by south, or east-south-east, lies Mednoi Ostroff, or Copper Island, so called from large masses of native copper being found upon the beach. To the south-east of Copper Island lie three small islands, Attak, or Attoo, Semitshi, and Agattoo, called by the Russians *Plishnie Ostrova*, or the nearest Aleutian Islands. Of these Attak is the largest; it is nearly of the same shape as Behring's Island, but rather more extensive, stretching from west to east to the length of 18 leagues. These islands are situate between 54° and 55° of north latitude. Attak has two harbours, one of which lies on the southern coast. From the eastern extremity of the Aleutian Islands, properly so called, another group runs south-eastward, continuing the chain as far at the western extremity of the Fox Islands. These are called the Andreanofskie Islands; but we have less accurate information respecting this central part of

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the chain, than regarding the eastern and western groups. They are said to lie within the 52d and 54th degree of north latitude, to be of inconsiderable extent or importance, and, therefore, seldom visited by recent navigators. The most remarkable are, Takavangha, which has in its centre, near the northern coast, a burning mountain; Kanaghi, or Kanaga, likewise with a high smoking mountain; Ayag, which has a number of good bays and anchoring-places; and Tshetchina, on which a high white mountain overtops the rest, which apparently is an extinct volcano, as there are still hot springs on this island. Atshak, or Atchka, and Amlac, are also usually reckoned among the number of the Andrenovian isles. The former greatly resembles Copper Island, and is provided with a commodious harbour.

By far the most important and best explored portion of this archipelago is the most easterly group, called by the Russians *Lyssie Ostrova*, or the Fox Islands. Of these islands the most considerable are, Umnak, Unalashka, or Oonalashka, and Unimak; the last of which is separated by a narrow strait from the promontory of Alaska. Beyond these, to the north-east, lies the large island of Kadyak, or Kodiak, which is generally included among the group called Schumagin's Islands.

The whole of the islands composing this chain are bare and mountainous; their coasts are rocky and surrounded by breakers, which renders the navigation of those seas exceedingly dangerous. The land rises immediately from the coasts to steep bald mountains, gradually ascending higher behind each other, and assuming the appearance of chains of mountains, with a direction lengthwise of the island. Springs take their rise at the bottom of the mountains, and either flow in broad and rapid streams into the neighbouring sea, or, collecting in the rocky vales and glens, form ample lakes, which send off their superfluous waters, by natural canals, into the adjacent bays. These islands bear evident marks of volcanic formation; and several of them have still active volcanoes, which continually emit smoke, and sometimes flames. No traces of metals have been discovered on these islands; but carneoles and sardonyxes are brought from thence. Their soil is said to be similar to that of Kamtschatka; and affords the same kinds of edible wild berries and roots; excepting some few vegetables which seem to be of foreign origin. No wood of any considerable growth has been perceived upon any of these islands, except a very small quantity on Unalashka. The land animals are bears, wolves, river-otters, river-beavers, and ermines. The sea-otter, so valuable on account of its skin, is frequently caught; but the number of these animals, it is believed, is much diminished of late. On the Fox Islands they have a great variety of foxes, black, grey, red, and brown. The sea abounds with all sorts of seals, dolphins, and whales; sea-lions and porpoises are rare, and sea-cows not at all to be seen. Salmon are caught in great abundance and variety; and halibut of an immense size are frequently taken. The winter upon these islands is tolerably mild, but the summer is equally short and unpleasant. The inhabitants are pretty numerous, and tributary to Russia, from whence vessels are sent out, and establishments formed upon these islands, on account of the very profitable chace of sea-otters and foxes.

Island of Unalashka.

Unalashka, one of the largest of the Fox Islands, was visited by Captain Cook during his last voyage, and seems to merit particular notice. This island stretches from north-east to south-west, and is from 70 to 80 versts in length, but of very unequal breadth. On the north and north-east side there are many bays and creeks, in some of which are very secure harbours for vessels. A part of the south-west shore consists of very high, steep, inaccessible cliffs; and another part has remained hitherto wholly unexplored. The whole island consists of a mass of rocks, covered only with a very thin coat of earth; the hills are of very unequal height, and are intersected by irregular vallies, the soil of which is commonly argillaceous, or an earth which appears washed down from the hills. In the lower vallies there is great abundance of grass, which would furnish very good food for cattle; indeed Captain Cook was of opinion that cattle might subsist at Unalashka all the year round, without being housed; and the soil, in many places, appeared capable of producing grain, roots, and vegetables. But the Russian traders, and the natives, seem satisfied with what nature brings forth. No wood grows on this and the neighbouring islands; only low bushes and shrubs of dwarf-birch, willow, and alder. For all the timber used for the purposes of building, &c. they are indebted to the sea, which wafts it to their shores from the adjacent continent of America. The inhabitants are rather low of stature, but plump and well shaped; with short necks, swarthy chubby faces, black eyes, small beards, and long, straight, black hair, which the men wear loose behind, and cut before, but the women tie up in a bunch. With regard to their character, Captain Cook describes them as, to all appearance, the most inoffensive people he ever met with, and perfect patterns of honesty. But, according to the accounts of the first discoverers, this does not seem to have been their original disposition; and recent travellers have observed, that although generally kind-hearted and peaceable, yet, when roused to anger, they become exceedingly malevolent, and indifferent to all danger, even to death itself.

Character of the Natives.

Dress.

The clothing of the men and women is nearly the same, and consists of a sort of frock or shirt, called *parka*, fastened round the neck with a broad stiff collar, and descending below the knee. These garments are made of the skins of seals, prepared in a manner peculiar to themselves, and sewed together very ingeniously. Though simple in their form, they are ornamented in a variety of ways; with glass beads; beaks of sea parrots; long white goat's hair, brought from Siberia, or small red feathers. Over the frock, the men sometimes bear a *kamleika*, or rain-garment. This is made of gut, which is water-proof; and has a hood to it, which draws over the head, and is tied under the chin. When on shore, the men wear boots, made of seal's skin; and they all have a kind of oval snouted cap, made of wood, with a rim to admit the head. These caps are dyed with green and other

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colours, and are very fancifully ornamented with ivory figures, carved from the teeth of the sea-cow, with glass or amber beads, and with the bristles from the beard of the sea-lion. They make use of no paint; tatooing was formerly very much in use among them, particularly among the women; but their intercourse with the Russians has rather brought this practice into disrepute. Both men and women, particularly the latter, bore the under lip, and insert pieces of bone or other ornaments; but this practice has also decreased of late. The women, for the most part, go barefooted; they wear bracelets of glass beads just above the wrist and ankle-joints, and are very fond of rings upon their fingers.

Food.

The principal food of these islanders consists of fish, sea-animals, birds, roots and berries. They dry large quantities of fish in summer, which they lay up in small huts for winter use; and roots and berries are also preserved for the same time of scarcity. Among the fish, the most common and most abundant are several sorts of salmon, cod, herrings, and halibut. The last is the most esteemed, and is sometimes caught of an enormous size. The fat of the whale is also a favourite species of food; when it grows old and rancid, it serves to light and warm their houses. They eat almost every thing raw; but of late, they have learnt some simple modes of cookery from the Russians. Vegetable food does not appear to be held in much esteem by the Unalashkans. That sweet plant, the Siberian parsnip, (*Heracleum Sibericum)*, is but little eaten, any more than the bulb of the *Saranna*, or Kamtschadale lily. Berries of an eatable quality abound; such as bramble-berries, cran-berries, hurtle-berries, heath-berries, and several others. Of late, the Russians have begun to plant potatoes, which succeed extremely well, and are much liked by the people.

Habitations.

The habitations of the Unalashkans are holes dug in the earth, covered with a wooden roof, over which they throw grass and earth; so that a village has the appearance of an European church-yard full of graves. The entrance into these huts is from the roof; some of the largest, however, which are inhabited by the Russians, have a low door in the side. The light is also admitted by the roof, through an opening or window covered over with seal's entrails, or dried fish-skin. Several divisions are made within, by means of seal-skins or straw-mats, which separate the apartments of the different families that occupy the habitation.

Household-Furniture.

Their household-furniture consists of bowls, spoons, buckets, piggins or cans, matted baskets, and perhaps a Russian kettle or pot. The knife and the hatchet, or rather a small flat piece of iron, made like an adze, by fitting it into a crooked wooden handle, are the only iron tools found amongst them. Yet all their instruments and utensils are made with the greatest neatness, and the most exact symmetry.

Needle-work and Embroidery.

The needles, with which they sew their clothes and embroider, are made of the wing-bone of the gull, with a very nice cut round the thicker end, instead of an eye, to which they tie the thread so skilfully, that it follows the needle without any obstruction. Their thread is made of the sinews of the seal, the fibres of which they split to the thickness which each sort of work requires. All sewing is performed by the women; they are the tailors, shoemakers, and boat-builders, or boat-covers. At their leisure hours, particularly in long winter evenings, they make fine mats, little baskets, and pocket-books of straw, that are both beautiful and strong. Indeed, Captain Cook observes, there is a neatness and perfection in most of their work, that shows they neither want ingenuity nor perseverance.

Use of Fire and Modes of producing it.

Their houses have no fire-place, but are heated, as well as lighted, by lamps. These are made of a flat stone, hollowed on one side like a plate; in the hollow part they put the oil, mixed with a little dry grass, which serves the purpose of a wick. They produce fire both by collision and by attrition; the former by striking two stones one against another, one of them being previously rubbed with brimstone. The latter method is with two pieces of wood; one of which is a pointed stick, and the other a flat piece. The pointed end of the stick they press upon the other, whirling it nimbly round as a drill; thus producing fire in a few minutes.

Occupations.

The principal occupations of the Aleutians, are fishing and hunting, and preparing the implements necessary for both. Their *baidars, baidarkas*, or boats, resemble the canoes of other savages. They consist of a skeleton of wood, over which is stretched a leather covering made of seals' skins. The boats of the Unalashkans are much superior in point of beauty to those of any of the other islands; some of them appear so transparent that one might trace the formation of the inside, and the manner in which the rower sits. In their form, they are long and narrow, and commonly hold only one person; sometimes they are made to hold two, and very rarely three; each person sitting in a round hole just fitted to the size of the body. The whole canoe is so extremely light, even when sodden with water, that it may be carried with ease in one hand. They are impelled by means of double paddles, seven or eight feet long, which are managed with great dexterity. Experienced navigators will sometimes venture out a considerable way to sea in these boats, even in very stormy weather.

Darts used in Hunting.

The darts, or javelins, with which they kill their game, are formed with the same neatness as their other instruments, and adapted with the greatest judgment to the different objects of the chace. For land animals, a single barbed point; for birds, three points of light bone, spread, and barbed; for seals, &c. they use a false point, inserted in a socket at the end of the dart, which parts on the least effort of the animal to dive, remaining in its body. A string of considerable length is fastened to this barbed point, and twisted round the wooden part of the javelin. This serves as a float to direct them to the seal, which, having the stick to drag after it, soon tires, and becomes an easy prey.

Curious method of throwing them.

These darts are not shot from a bow, but slung from a small plank, about 18 inches long and two inches broad. In order that the weapon may be held the faster, they have a sort of handle at the lower end, and an opening through which the fore-finger is thrust. At the other end is a small channel, into which the javelin fits with a little knob, which serves to retain it When the javelin is to be thrown, the plank is held horizontally, and the aim being taken, the weapon is directed by the middle finger and thumb. This is done

Aleutian Islands. with so much dexterity, and the motion given to it is so powerful and so rapid, that the object aimed at is rarely missed; even whales are killed without any other weapon.

Amusements. Their favourite amusement appears to be dancing; in which, however, they do not seem to exhibit any particular exertion of strength, or expression of elegance; the only motion being a sort of hop, the performer scarcely moving from the place he first takes up. Their music is exceedingly rude, consisting of a small drum or tambour, and a rattle made of the bladder of a sea-dog, filled with peas or small pebbles. Mechanical skill. In their leisure hours, they amuse themselves with making these little drums and rattles, which are frequently ornamented with a good deal of ingenuity and elegance; and with cutting out from the teeth of the sea-cow, small figures of men, fish, sea-otters, and other objects, in a manner that appears very extraordinary, considering that the sea-cow's teeth are much harder than ivory, and that they have no proper tools to work with.

Religion. The religion of these Islanders, like that of most uncivilized nations, consists in superstitious observances, and a belief in charms. Many of them have been baptized, and are nominally professors of the Greek faith; of which, however, they understand nothing more than Marriages. making the sign of the cross. They have no marriage ceremony; every man may have as many wives as he can conveniently maintain; if his means decrease, he sends first one, then another back to their parents; and these women become perfectly at liberty to look out for other husbands. Sometimes the same woman lives with two husbands; and it is not uncommon for men to sell or exchange wives. Boys, if they happen to be very handsome, are often brought up entirely in the manner of girls; instructed in the arts of female blandishment; and used as concubines. This shocking, unnatural, and immoral practice, has prevailed here even from the remotest times. Burials. Such men are known under the name of *schopans*. The bodies of the dead, especially of the men, were formerly interred in places set apart for the purpose, and with particular ceremonies. Their best javelins and clothes, with a portion of train-oil and other articles of food, were laid with them in the grave; and sometimes even slaves of both sexes were slaughtered upon the occasion. These customs are now, however, entirely laid aside.

Population and Government. The population of Unalashka, and the neighbouring islands, appears to have been formerly considerable, amounting to several thousands. In 1790, Sarytcheff reckoned it at 1300. According to the most recent accounts, it does not appear to amount to more than 300. This rapid depopulation is ascribed partly to the practice of sending the best hunters from hence to a distance, to chace the large sea-otters, few of whom ever return again to their families; and partly to the state of oppression under which the natives live, and the change which has taken place in their modes of living. Captain Cook seems to consider the natives of these Islands as originally of the same extraction with the Greenlanders and Esquimaux. When first discovered by the Russians, they were under the government of *Toigons*, or chiefs, who, however, possessed little superior distinction or dignity, and had no revenue. At present they are all subject to the government of the Russian settlers.

Russian settlements, Throughout the whole of the Aleutian Islands, on the island of Kadyak, and the western coast of America, the Russians have formed settlements for the purpose of hunting, and collecting furs; with which they carry on a lucrative commerce, particularly with the Chinese. The most valuable fur is that of the sea-otter; an animal which has now become rare on these islands, in consequence of the extreme eagerness with which they have been hunted and killed. Besides the sea-otter, there are numbers of foxes, especially on the Fox Islands. The black foxes found on these islands are not so valuable as those of Siberia. The Arctic, or ice fox, called also the rock fox, and the blue fox, from the natural colour of the fur, which is of a blueish grey, is very common. and commerce. From the first discovery of these islands by Behring and Tscherikoff, in 1741, the fur-trade was carried on for a long period entirely by private adventurers; and appears to have been productive of great abuses. The natives were frequently treated in the most cruel and barbarous manner; and the keenness displayed by these rapacious hunters, threatened to extirpate the race of animals upon which the trade depended. Convinced of the extreme necessity of putting a stop to this destructive plan of proceeding, Schelikoff, an intelligent Russian merchant, took considerable pains to unite the different partakers of this trade into a company, in order that it might be conducted with prudence and precaution, upon some plan that might prove advantageous to all parties. Establishment of the Russian American Company. In 1785, he succeeded in joining company with the Golikoffs. They increased their capital, and fitted out several ships, which the enterprizing Schelikoff commanded in person. Factories, protected by forts, were established in almost all the Aleutian islands, as far eastward as Kadyak; and, during several years, they continued this lucrative trade in conjunction, by which they acquired considerable wealth. The success of this connection induced several merchants to unite like Schelikoff and the Golikoffs; and, in this manner, was laid the foundation of the present *Russian American Company*. The irregular manner, however, in which the trade was still carried on, and the cruelty which was frequently exercised by the Russian merchants towards the natives of the islands, drew upon them great and well-founded censure; insomuch, that the Emperor Paul determined to put an end to the company and the trade at the same time. This determination would have infallibly been carried into effect, but for the interference of M. Von Resanoff, who had married Schelikoff's daughter, and was personally interested in the successful continuance of the American Company. In consequence of his active interposition, the new established company was formally confirmed, in 1799, with considerable privileges. On the accession of the present Emperor, his Majesty interested himself very much in behalf of the company, of which he became a member, and thus induced many of the nobility to follow his example; and by means of the active superintendence of the minister, Count Romanzoff, and the Commer-

Aleutian Islands || Alfarabius.

cial Counsellor Benedict Cramer, this branch of the Russian commerce has undergone several advantageous changes. But, according to the accounts of recent observers, many abuses still exist which loudly call for correction. The miserable situation of the *Promüschleniks*, or fur-collectors, themselves the slaves of the company's agents, and exercising, in their turn, the most oppressive tyranny over the wretched Aleutians, has been represented by several eye-witnesses in the most deplorable colours. It is to be hoped, that these representations may attract the serious attention of the Russian Government; and that the information which the late voyages have brought to light, with regard to the evils connected with the present system of management, may lead to the adoption of measures, tending at once to the better regulation of the trade, and to the amelioration of the condition of those remote settlements.

Present state of the trade and Settlements.

They who are desirous of obtaining more ample information on the subject of this article, may consult the following works: Müller's *Samlung Russischer Geschichte;* particularly the third volume. *Neue Nachrichten von denen neuentdeckten Insuln in der See zwischen Asia und America, &c. verfasset von J. L. S.*—Hamburgh and Leipsic, 1776. Coxe's *Account of the Russian Discoveries.* Tooke's *View of the Russian Empire.* The *Voyages* and *Travels* of Billings; Sarytcheff; Cooke; Meares; Dixon; Vancouver; La Peyrouse; Mackenzie; Krusenstern; Lisiansky; and Dr Langsdorff. (H.)

ALFARABIUS, a celebrated Eastern philosopher of the tenth century, was born, in what year is not known, at Farab, a city of Asia Minor, now called Othrar. He studied for sometime at Bagdad, then the chief seat of learning; and afterwards travelled, in order to form an acquaintance with the learned of other countries.

A great revolution of sentiment in regard to letters, had taken place, in the preceding century, among the followers of Mahomet. The Commanders of the Faithful had become the patrons and cultivators, instead of the scourgers and contemners, of science and literature. Knowledge found her only sanctuary under the successors of those rulers who had sought to extinguish every ray of intellectual light, by means of the destruction of the libraries of Alexandria. Instead of proscribing every book as useless but the Koran, some of these rulers carried their zeal in the cause of learning so far, as to make the acquisition of Greek manuscripts an object of negotiation, in their treaties with the Emperors of Constantinople. Under the Caliphs of the house of Abbas, men of learning were raised to a degree of favour and consequence, which has never been enjoyed by that class, under the sovereigns of any other country, in any age of the world. The munificence which shone forth with so much lustre in the supreme depositaries of power, was widely emulated among the inferior rulers and governors; and "this emulation," to use the words of Gibbon, "diffused the taste and the rewards of science, from Samarcand and Bochara, to Fez and Cordova." Every little court had its circle of men of letters, who were always admitted to the society of the Prince, and for the most part liberally supported by his bounty. Thus, when Alfarabius, after he had finished his travels, came to settle at Damas, he was received with open arms by its sovereign, who bestowed upon him a pension, which he continued to enjoy till his death, in the year 950.

Alfarabius || Alfergan.

But to gain the notice of princes, or to acquire wealth, formed none of the aims of this philosopher. He is said to have led a very retired and ascetic life, rather contemning than seeking after the good things of the world. "He constantly slept, even during winter, upon straw; his countenance was always sorrowful, and he found no consolation in any thing but philosophy." (Enfield's *Hist. of Philosophy*, B. v. c. 1.) His works were numerous, and very various in their subjects; his speculations seem, indeed, from the list of his writings, to have embraced the whole circle of the sciences. He is particularly deserving of notice, as having been perhaps the first compiler of an *Encyclopædia.* Such is the title of one of his works, of which there is a copy in manuscript, in the library of the Escurial. It contains, according to the brief notice of it given in Casiri's valuable account of the Arabic Manuscripts in that collection, a clear and comprehensive definition and compendium of all the Arts and Sciences; and it appears to have been regarded in the East as the most valuable of Alfarabius's compositions. It would have been agreeable to the lovers of literary history to have possessed some more detailed view of the extent, plan, and contents of an Encyclopædia, written by an Arabian, so many centuries before any work of that description was thought of in Europe.

Next to this in estimation appears to have been his treatise on *Music;* in which he is said to have applied the principles of physics to correct the errors of musical theorists, and to regulate the construction of musical instruments. (*Biog. Universelle*, Tom. I.) Casiri gives a complete list of his writings; but it is too long to be copied in this place. (See *Bibl. Arabico-Hispana Escurialensis*, Tom. I.) Some of his pieces were published, in the Latin tongue, at Paris, in 1638, under the title of *Opuscula Varia* Alfarabii.

ALFERGAN, or ALFRAGAN, an Arabian astronomer, who lived under the reign of the Caliph Almamon, and who, on account of his skill in calculation, was surnamed the *Calculator*. He wrote an *Introduction to Astronomy*, which contains little that is original, being chiefly compiled from the *Almagest* of Ptolemy. He was also the author of a treatise on *Dials*, and of an account of the construction and use of the *Astrolabe*. These two pieces still remain in manuscript; but there have been three different Latin translations published of his astronomical work. The first, by Joannes Hispalensis, was published at Ferrara in 1493. This translation was afterwards reprinted at Nuremberg in 1537, with a preface by Melanchton. The second was the work of John Christman, and was published at Frankfort in 1590. The third, and the most esteemed of these translations, was by Golius, Professor of Mathematics and Oriental Languages at Leyden. It was published at Amsterdam in 1669, accompanied with the Arabic text, and with notes by Golius, which are extremely curious. But these notes extend no farther than the ninth chapter, as the author did not live to complete

this part of his undertaking. The work itself contains thirty chapters, all of which are very short.

ALFIERI (VICTOR), chiefly celebrated as the author who raised the Italian tragic drama from its previous state of degradation, was born on the 17th January 1749, at the town of Asti in Piedmont. He lost his father in early infancy; but he continued to reside with his mother, who married a second time, till his tenth year, when he was placed at the academy of Turin. After he had passed a twelvemonth at the academy, he went on a short visit to a relation who dwelt at Coni, and during his stay there, he made his first poetical attempt in a sonnet chiefly borrowed from lines in Ariosto and Metastasio, the only poets he had at that time read. When thirteen years of age he was induced to commence the study of civil and canonical law; but the attempt only served to disgust him with every species of application, and to increase his relish for the perusal of French romances.

By the death of his uncle, who had hitherto taken some charge of his education and conduct, he was left, at the age of fourteen, to enjoy without controul his vast paternal inheritance, augmented by the recent accession of his uncle's fortune. He now began to attend the riding-school, where he acquired that rage for horses, and equestrian exercise, which continued to be one of his strongest passions till the close of his existence.

After some time spent in alternate fits of extravagant dissipation, and ill-directed study, he was seized with a desire of travelling; and having obtained permission from the king, he departed, in 1766, under the care of an English preceptor. Restless and unquiet, he posted with the utmost rapidity through the towns of Italy; and his improvement was such as was to be expected from his mode of travelling and his previous habits. Dissatisfied with himself, he felt as little relish for spectacles or entertainments as for literature; and was as little amused by the gaiety of a carnival at Naples, as he was impressed by the remains of antiquity at Rome, or the exhibitions of modern art at Florence and Bologna. This indifference and insensibility did not, however, arise from defect of talent or the natural powers of taste, but from the want of some serious passion, or some ennobling or praiseworthy pursuit. Hoping to find in foreign countries some relief from the tedium and *ennui* with which he was oppressed, and being anxious to become acquainted with the French Theatre, he proceeded to Paris; but his feelings were only those of disgust or indifference for the dramas which he saw represented in that capital. He seems, indeed, to have been completely dissatisfied with every thing he witnessed in France, and contracted a dislike to its people, which his intercourse in future years rather contributed to augment than diminish. In Holland he became deeply enamoured of a married lady, who returned his attachment, but who was soon obliged to accompany her husband to Switzerland. Alfieri, whose feelings were of the most impetuous description, was in despair at this separation, and returned to his own country in the utmost anguish and despondency of mind. While under this depression of spirits, he was induced to seek alleviation from works of literature; and the perusal of Plutarch's Lives, which he read with profound emotion, inspired him with an enthusiastic passion for freedom and independence. Under the influence of this rage for liberty he recommenced his travels; and his only gratification, in the absence of freedom among the Continental States, appears to have been derived from contemplating the wild and sterile regions of the north of Sweden; where gloomy forests, lakes, and precipices, conspired to excite those sublime and melancholy ideas which were congenial to his disposition. Human manners and human institutions he seems invariably to have surveyed with an eye of passion or prejudice, instead of viewing them with the calmness of a philosopher, who meditates how they may be rectified, or what lessons may be drawn from them. In every country his soul felt as if confined by the bonds of society; he everywhere panted for something more free in governments, more elevated in sentiment, more devoted in love, and more perfect in friendship. In search of this ideal world, he posted through various countries, more with the rapidity of a courier, than of one who travels for amusement or instruction. During a journey to London, he engaged in an intrigue with a married lady of high rank; and having been detected, the publicity of a rencounter with the injured husband, and of a divorce, which followed, united to the knowledge he now acquired of the infamous character of the woman, to whom he was ardently attached, rendered it expedient and desirable for him to quit England. He then visited Spain and Portugal, where he became acquainted with the Abbé Caluso, who remained through life the most attached and estimable friend he ever possessed. In 1772, Alfieri returned to Turin, where he again became enamoured of a lady, whom he loved with his usual ardour, and who seems to have been as undeserving of a sincere attachment as those he had hitherto adored. In the course of a long attendance on his mistress, during a malady with which she was afflicted, he one day wrote a dialogue, or scene of a drama, which he left at this lady's house. About a year after, on a difference taking place between them, this piece was returned to him. Having then retouched and extended it to five acts, it was performed at Turin in 1775, under the title of *Cleopatra*, whose amours had always been a favourite subject with Italian dramatists.

From this moment, Alfieri was seized with an immeasurable thirst of theatrical fame, and the remainder of his life was devoted to its attainment. His two first tragedies, *Filippo* and *Polinice*, were originally written in French prose; and when he came to versify them in Italian, he found that, from his Lombard origin, and long intercourse with foreigners, he expressed himself with feebleness and inaccuracy. Accordingly, with the view of improving his Italian style, he went to Tuscany, and, during an alternate residence at Florence and Sienna, he completed his *Filippo* and *Polinice*, and conceived the plan of various other dramas. While thus employed, he became acquainted with the Countess Albany, who then resided with her husband at Florence. For her he formed an attachment, which, if less violent

Alfieri.

than his former loves, appears to have been more permanent. With this motive to remain at Florence, he could not endure the chains by which his vast possessions bound him to Piedmont. He therefore resigned his whole property to his sister, the Countess Cumiana, reserving an annuity, which scarcely amounted to a half of his original revenues. At this period, the Countess Albany, urged by the ill treatment she received from her husband, sought refuge in Rome, where she at length received permission from the Pope to live apart from her tormentor. Alfieri followed the Countess to that capital, where he completed fourteen tragedies, four of which were now for the first time printed at Sienna.

At length, however, it was thought proper, that, by leaving Rome, he should remove the aspersions which had been thrown on the object of his affections. During the year 1783, he therefore travelled through different states of Italy, and published six additional tragedies. The interests of his love and literary glory had not diminished his rage for horses, which seems to have been at least the third passion of his soul. He went to England solely for the purpose of purchasing a number of these animals, which he brought with him to Italy. On his return, he learned that the Countess Albany had gone to Colmar in Alsace, where he joined her, and resided with her under the same roof during the rest of his life. They chiefly passed their time between Alsace and Paris; but at length took up their abode entirely in that metropolis. While here, Alfieri made arrangements with Didot for an edition of his tragedies; but was soon after forced to quit Paris by the storms of the Revolution. He recrossed the Alps with the Countess, and finally settled at Florence. The ten last years of his life, which he spent in that city, seem to have been the happiest of his existence. During that long period, his tranquillity was only interrupted by the entrance of the Revolutionary armies into Florence in 1799. Though an enemy of kings, the aristocratic feelings of Alfieri rendered him also a decided foe to the principles and leaders of the French Revolution; and he rejected, with the utmost contempt, those advances which were made with a view to bring him over to their cause. The concluding years of his life were laudably employed in the study of Greek literature, and in perfecting a series of comedies. His assiduous labour on this object, which he pursued with his characteristic impetuosity, exhausted his strength, and brought on a malady, for which he would not adopt the prescriptions of his physicians, but obstinately persisted in employing remedies of his own. Under this regimen his disorder rapidly increased, and at length terminated his life on the 8th October 1803, in the fifty-fifth year of his age.

The character of Alfieri may be best appreciated from the portrait which he has drawn of himself in his own *Memoirs of his Life*. He was evidently of an irritable, impetuous, and almost ungovernable temper. Pride, which seems to have been a ruling sentiment, may account for many apparent inconsistencies of his character. While it made him abhor kings, because superior to himself, it led him to detest those republicans who, by too near an approach, contaminated aristocratic dignity; and it induced him, while yet undistinguished himself, and panting for literary fame, to decline a proffered introduction to Metastasio and Rousseau. But as all his bad qualities were greatly softened by the cultivation of literature, it may be presumed, that a better education, and an earlier employment of his faculties, would have rendered him a much more perfect character. His application to study gradually tranquillized his temper, and softened his manners; leaving him, at the same time, in perfect possession of those good qualities which he had inherited from nature;—a warm and disinterested attachment to his family and friends, united to a generosity, vigour, and elevation of character, which rendered him not unworthy to embody in his dramas the actions and sentiments of Grecian heroes.

To these dramas Alfieri is chiefly indebted for the high reputation to which he has attained. Before his time, the Italian language, so harmonious in the *Sonnets* of Petrarch, and so energetic in the *Commedia* of Dante, had been invariably languid and prosaic in dramatic dialogue. The pedantic and inanimate tragedies of the sixteenth century were followed, during the iron age of Italian literature, by dramas, of which extravagance in the sentiments, and improbability in the action, were the chief characteristics. The prodigious success of the *Merope* of Maffei, which appeared in the commencement of the last century, may be attributed more to a comparison with such productions, than to intrinsic merit. In this degradation of tragic taste, the appearance of the tragedies of Alfieri was, perhaps, the most important literary event that had occurred in Italy during the eighteenth century. On these tragedies it is difficult to pronounce a judgment, as the taste and system of the author underwent considerable change and modification during the intervals which elapsed between the three periods of their publication. An excessive harshness of style, an asperity of sentiment, and total want of poetical ornament, are the characteristics of his four first tragedies, *Filippo*, *Polinice*, *Antigone*, and *Virginia*. These faults were, in some measure, corrected in the six tragedies which he gave to the world some years after; and in those which he published along with *Saul*, the drama which enjoyed the greatest success of all his productions;—a popularity, which may be partly attributed to the severe and unadorned manner of Alfieri being well adapted to the patriarchal simplicity of the age in which the scene of the tragedy is placed. But though there be a considerable difference in his dramas, there are certain observations applicable to them all. None of the plots are of his own invention. They are founded either on mythological fable or history; most of them had been previously treated by the Greek dramatists, or by Seneca. *Rosmunda*, the only one which could be supposed of his own contrivance, and which is certainly the least happy effusion of his genius, is partly founded on the eighteenth novel of the third part of Bandello, and partly on Prevost's *Mémoires d'un Homme de Qualité*. But whatever subjects he chooses, his dramas are always formed on the Grecian model, and breathe a freedom and independence worthy an Athenian poet. Indeed, his *Agis* and *Bruto* may rather be considered oratorical declamations and dialogues on liberty than tragedies. The unities of time and place are not so scru-

pulously observed in his, as in the ancient dramas; but he has rigidly adhered to a unity of action and interest. He occupies his scene with one great action, and one ruling passion, and removes from it every accessary event or feeling. In this excessive zeal for the observance of unity, he seems to have forgotten, that its charm consists in producing a common relation between multiplied feelings; and not in the bare exhibition of one, divested of those various accompaniments which give harmony to the whole. Consistently with that austere and simple manner which he considered the chief excellence of dramatic composition, he excluded from his scene all *coups de théâtre*, all philosophical reflections, and that highly ornamented versification, which had been so assiduously cultivated by his predecessors. In his anxiety, however, to avoid all superfluous ornament, he has stripped his dramas of the embellishments of imagination; and for the harmony and flow of poetical language, he has substituted, even in his best performances, a style, which, though correct and pure, is generally harsh, elaborate, and abrupt;—often strained into unnatural energy, or condensed into factitious conciseness. The chief excellence of Alfieri consists in powerful delineation of dramatic character. In his Philip II. he has represented, almost with the masterly touches of Tacitus, the sombre character, the dark mysterious counsels, the *suspensa semper et obscura verba* of the modern Tiberius. In *Polinice* the characters of the rival brothers are beautifully contrasted; in *Maria Stuarda*, that unfortunate Queen is represented unsuspicious, impatient of contradiction, and violent in her attachments. In *Mirrha*, the character of *Cynaras* is perfect as a father and king, and *Cenchris* is a model of the virtues of a wife and mother. In the representation of that species of mental alienation where the judgment has perished, but traces of character still remain, he is peculiarly happy. The insanity of Saul is skilfully managed; and the horrid joy of Orestes in killing Egisthus rises finely and naturally to madness, in finding that, at the same time, he had inadvertently slain his mother.

Whatever may be the merits or defects of Alfieri, he may be considered as the founder of a new school in the Italian drama. His country hailed him as her sole tragic poet, and his successors in the same path of literature have regarded his bold, austere, and rapid manner, as the genuine model of tragic composition.

Besides his tragedies, Alfieri published during his life many sonnets, five odes on American independence, and the poem of *Etruria*, founded on the assassination of Alexander I. Duke of Florence. Of his prose works, the most distinguished for animation and eloquence is the *Panegyric on Trajan*, composed in a transport of indignation at the supposed feebleness of Pliny's eulogium. The two books, entitled *La Tiranide* and the *Essays on Literature and Government*, are remarkable for elegance and vigour of style, but are too evidently imitations of the manner of Machiavel. His *Antigallican*, which was written at the same time with his *Defence of Louis XVI.*, comprehends a historical and satirical view of the French revolution. The posthumous works of Alfieri consist of satires, six political comedies, and the *Memoirs of his Life*;—a work which will always be read with interest, in spite of the cold and languid gravity with which he delineates the most interesting adventures and the strongest passions of his agitated life. See *Mem. de Vitt. Alfieri.—Sismondi de la Litt. du Midi de l'Europe.*—Walker's *Memoir on Italian Tragedy.—Giorn. de Pisa.* Tom. LVIII. (M.)



ALHAZEN, an Arabian author of the eleventh century, who is better entitled to the appellation of philosopher, than most of those of his countrymen by whom it has been obtained. The place of his birth was Bassorah; the year, uncertain; but his death took place at Cairo in 1038. There was another author of the same name, who translated the *Almagest* of Ptolemy; but that writer lived during the reign of the Caliph Almamon. In some accounts of Alhazen, we find it said, that he lived in Spain; but it appears from Casiri, (*Bibl. Arabico-Hispana Escurialensis*), that, after he left his native city, Egypt was his place of residence. It also appears, that he was invited to that country by one of the Fatemite Caliphs; and that the reason was, some boasts which he had made of being able to obviate the evils attendant upon the overflowing, as well as the decrease of the waters of the Nile. He surveyed the country with a view to this project, to aid which, every thing that he asked was liberally furnished by the Caliph; but finding that his imagination had seduced him into a wild and impracticable scheme, he feigned madness, thereby to avoid the punishment which he dreaded; and he continued to play this humiliating part till the Caliph's death relieved him from his apprehensions.

But whatever figure he may have made as a projector, there can be no doubt that he was a skilful geometrician; and that his name deserves a conspicuous place among the improvers of the science of optics. He was not a mere compiler from the ancients, or commentator upon their works; he followed the bent of his own genius; and, striking into the right path of experiment and observation, his inquiries were productive of a real accession to the stock of knowledge, in regard to some of the most interesting phenomena of nature. He refuted the error of the ancient philosophers, that vision was produced by rays emitted from the eye. He gave the first sensible explanation of the cause of the apparent increase of the sun and moon when seen near the horizon; showing that this is occasioned by their being then supposed, owing to the number of intermediate objects, to be at a greater distance from the spectator. He was the first who applied the laws of refraction, to show how the heavenly bodies are sometimes seen as if above the horizon when still below it; and who, in the same way, explained the cause of the morning and evening twilight;—of that beneficent provision of nature, by which the glories of day are made gradually to approach, and gradually to withdraw. These dioptrical discoveries of the Arabian philosopher have furnished M. Bailly with one of the many fine passages which embellish his celebrated work on the History of Astronomy. (*Astron. Moderne*, L. vi. sect. 20.)

As a writer, Alhazen is censurable for unmeaning prolixity, and scholastic subtlety. It appears, from

Casiri, that his works were numerous; but only two of them have been published, namely, his Treatise on *Optics*, and that on the *Twilight*. They were both published in Latin, in 1572, by Frederic Risner, under the title of *Opticæ Thesaurus*.

ALIMENTS. See Food in the Encyclopædia, and Dietetics in this Supplement.

ALKALIMETER, a name given to a small instrument, invented by M. Descroizilles, for ascertaining the value of the alkalis in commerce. There is an account of it in the 60th volume of the *Annales de Chimie*, which is translated in the 28th volume of Tilloch's *Philosophical Magazine*.

ALLAN (David), a Scotch historical painter of considerable celebrity, was born at Alloa, on the 13th February 1744. At a very early age he showed such marks of genius as attracted the notice of some gentlemen living in the neighbourhood. In a remote part of the country, and deprived of the ordinary means of indulging his propensity to drawing, he betook himself, when a boy, to such implements and materials as he could readily procure; and the mechanical skill and taste which, in particular, he displayed in using his knife, have been mentioned as remarkable for his years. Mr Stewart, then Collector of the Customs at Alloa, having mentioned these proofs of natural talent to Mr Fowlis the Painter, who sometime before had instituted an Academy in Glasgow, for painting and engraving, invited young Allan to study under his care. Here he remained about seven years, studying the elementary principles of his art; and by the proficiency which he attained, justified the opinion of his talents, which had procured him admission to that ill-fated seminary. But, although, the public taste for the fine arts, which then existed in Scotland, was so feeble as to leave his preceptor without that support which his liberal and spirited efforts justly claimed, Allan, on leaving the academy, had the good fortune to gain the patronage of individuals, whose generosity enabled him to prosecute his views, and to improve his taste, by studying the works of art abroad. At the joint expence of several persons of fortune, particularly Lord Cathcart and Mr Abercrombie of Tullibody, he was enabled to go to Italy; and at Rome he devoted himself with great zeal to his profession. Here he remained for no less a period than sixteen years, during which time, his subsistence chiefly depended on the copies which he made from the most celebrated pictures of the ancient masters; but one original work which he then painted, does the highest credit to his talents, namely, his composition representing the *Origin of Painting*. On this picture, indeed, the fame of Mr Allan, as a historical painter, chiefly rests; and its merit was rewarded, by his receiving the gold medal given by the Academy of St Luke, in the year 1773, for the best specimen of historical composition. There is an excellent engraving of this piece by Cunego.

On his return to his native country, he took up his residence in Edinburgh, where he was appointed master of the Academy established by the Trustees for Manufactures in Scotland. There he executed a great variety of works, of various degrees of merit; but perhaps none such as might have been expected from the author of the *Origin of Painting*. Those, indeed, by which he is most known, are of a cast altogether different, being remarkable for the comic humour which they display. The *Scotch wedding*; the *Highland dance*; the *Repentance-stool*, with his *Illustrations of the Gentle Shepherd*, are all of this class, and so generally known, as to need no description. Four pictures representing the Carnival, are said to have been very successful. Of his graver compositions, the *Prodigal Son*, in possession of Lord Cathcart, and his *Hercules and Omphale*, in the possession of Mr Erskine of Mar, are regarded as works of great merit.

As an artist, Mr Allan possessed much facility of invention; with a keen discernment of those evanescent circumstances in the outward form, which mark the different shades of passion and affection in the mind. With the talent of artfully arranging the various parts of a crowded and bustling scene,—such as appears in some of his comic productions, he possessed that feeling for simplicity, which gives to his graver compositions, a classical and antique air of elegance. In his drawing he often was hasty and incorrect. He executed a great variety of etchings and drawings in water colour, which are valuable, on account of their excellent humour, and the great knowledge of national character which they express. Many of the original plates and drawings are now in the possession of Mr George Thomson, to whose kindness and friendship their author was much indebted. We do not know that Allan left any pupil who has followed his particular line in painting. Mr H. W. Williams received from him the rudiments of art, but his genius has directed him to a different course, which has conducted him to merited eminence as a landscape painter.

Mr Allan is remembered and spoken of as an excellent private character. He died at Edinburgh on the 6th of August 1796, in the 53d year of his age. (N.)

ALUM, a salt very much employed by Dyers and other artists, in their different processes. It has a white colour, an astringent and acid taste, and crystallizes in regular octahedrons. Its specific gravity is 1.731, according to a mean of the experiments of Fahrenheit, Wallerius, Watson, and Hassenfratz. Water at the temperature of 60° dissolves about one fifteenth of its weight of alum; while boiling water dissolves about three-fourths of its weight. When alum is exposed to a dry atmosphere, it effloresces slightly. When heated, it speedily becomes liquid. If the heat be continued, its water is driven off, and it loses about 44 *per cent.* of its weight. What remains, is a vitreous looking substance, known by the name of *burnt alum*. When alum is exposed to a strong red heat, it gives off a quantity of oxygen gas, as Dr Milner first ascertained. The same fact was afterwards pointed out by Gay-Lussac.

Alum is one of those substances which chemists have distinguished by the name of triple salts. It is composed of sulphuric acid, potash, alumina and water. That it contained sulphuric acid as a constituent, was known even to the Alchemists. Pott and Margraaf demonstrated, that alumina was another constituent. Mr Pott, in his *Lithogeognosia*, showed

Alum. that the earth of alum, or the precipitate obtained when an alkali is poured into a solution of alum, is quite different from lime and chalk, with which it had been confounded by Stahl. Margraaf went much farther. He not only showed that alumina is one of the constituents of alum; but that this earth possesses peculiar properties, is different from every other substance, and is one of the ingredients in common clay. (*Experiences faites sur la terre d'alun.* Margraaf's *Opusc.* II. 111.) Margraaf showed likewise, by many experiments, that crystals of alum cannot be obtained by dissolving alumina in sulphuric acid, and evaporating the solutions. The crystals formed are always soft, and quite different in their appearance from alum crystals. But, when a solution of potash or ammonia is dropt into this liquid, it immediately deposites perfect crystals of alum. (*Sur la regeneration de l'alun.* Margraaf's *Opusc.* II. 86.) He mentions likewise, that manufacturers of alum, in general, were unable to procure the salt without a similar addition; and that at first, it had been customary to add a quantity of putrid urine, and that afterwards a solution of carbonate of potash was substituted in its place. But subsequent chemists do not seem to have paid much attention to these important observations of Margraaf; they still continued, without any rigid examination, to consider alum as a sulphate of alumina.

Bergman indeed had observed, that the addition of potash or ammonia made the alum crystallize; but that the same effect was not produced by the addition of soda or of lime, (*De confectione aluminis.* Bergman's *Opusc.* I. 225.) He had observed likewise, that sulphate of potash is frequently found in alum. He decomposed the solution of alum by means of ammonia, evaporated the filtered liquid to dryness, and exposed the residue to a red heat. A quantity of sulphate of potash often remained behind in the crucible, (*Ibid*, p. 326.) He drew, as a conclusion from these facts, that sulphate of potash readily combines with sulphate of alumina. Yet, it is obvious from the whole of his dissertation, that he had no conception that alum is a triple salt. He ascribed the difficulty of crystallization, to the excess of sulphuric acid present. He thought that the only use of the potash was to saturate this excess; and advises manufacturers to substitute clay instead of potash, as a method which would not only saturate the excess of acid, but increase the quantity of alum. This very bad advice was not, we presume, followed by any alum makers. If they tried it, they would soon be convinced of its injurious consequences. Instead of alum, they would have obtained an insoluble tasteless powder, well known by the name of *alum saturated with its earth.*

After Klaproth had discovered the existence of potash as an ingredient in *leucite* and *lepidolite*, it occurred to Vauquelin, that it was probably an ingredient likewise in many other minerals. He recollected that alum crystals often make their appearance during the analysis of stony bodies; and, considering that alum cannot be obtained in crystals without the addition of potash, he began to suspect that this alkali constituted an essential ingredient in the salt. A set of experiments undertaken on purpose to elucidate this important point, soon satisfied him that his conjecture was well founded. Accordingly, in the year 1797, he published a dissertation, demonstrating that alum is a triple salt, composed of sulphuric acid, alumina and potash. (*Annales de Chimie*, XXII. 258.) Soon after, Chaptal published the analysis of four different kinds of alum, namely, Roman alum, Levant alum, British alum, and alum manufactured by himself. This analysis led to the same result as that of Vauquelin. (*Ann. de Chim.* XXII. 280.) Alum.

Since that time, alum has been admitted by chemists to be a triple salt; and various analyses of it have been made to determine its constituents. Vauquelin, (*Ann. de Chim.* L. 167), Thenard and Roard, (*Ibid. Tom.* LIX. 72), Curaudon, (*Journal de Physique*, LXVII. 1.) and Berzelius, (*Ann. de Chim.* LXXXII. 258.) successively published the results of their experiments. They differ but little from each other. We shall therefore satisfy ourselves with giving the analysis of Berzelius, which is the latest, and in all probability the most accurate. His result was as follows:

| | |
|---|---|
| Sulphuric acid - - | 34.23 |
| Alumina - - - - | 10.86 |
| Potash - - - - - | 9.81 |
| Water - - - - | 45.00 |
| Loss - - - - - | 0.10 |
| | 100.00 |

Or

| | |
|---|---|
| Sulphate of alumina - | 36.85 |
| Sulphate of potash - | 18.15 |
| Water - - - - - | 45.00 |
| | 100.00 |

Now, as we shall show in a subsequent article, (See Atomic *philosophy*), an integrant particle of sulphuric acid weighs 5, an integrant particle of alumina 2.136, and an integrant particle of potash 6. We shall show likewise in the same article, that sulphate of potash is composed of one integrant particle of sulphuric acid, united with one integrant particle of potash; and sulphate of alumina of one integrant particle of sulphuric acid, united to one integrant particle of alumina; therefore, the relative weight of an integrant particle of each of these salts, is as follows:

| | |
|---|---|
| Sulphate of potash - | 11.000 |
| Sulphate of alumina - - | 7.136 |

But the quantities of each of these salts in alum, according to the preceding analysis, are as the numbers 18.15 : 36.85. Now, the ratio 18.15 : 36.85, is very nearly the same as 11 : 7.136 × 5. Hence it follows, that alum contains 1 integrant particle of sulphate of potash, and 5 integrant particles of sulphate of alumina. An integrant particle of water, as will be shown likewise in the article Atomic *philosophy*, weighs 1.132. Now, one integrant particle of sulphate of potash, × 5 integrant particles of sulphate of alumina, weigh 46.680. But alum con-

tains 45 *per cent.* of water. To find how many integrant particles of water these amount to, we have this proportion; 56 : 45 : : 46.680 : 38.213. Now, 38.213, is very nearly the weight of 34 integrant particles of water. For $1.132 \times 34 = 38.488$. Hence, it follows, that alum is a compound of

| | | |
|---|---|---|
| Sulphate of potash | - | 1 integrant particle. |
| Sulphate of alumina | - | 5 |
| Water | - - - - | 34 |
| | Total | 40 |

Making altogether no fewer than 40 integrant particles united together. It is not easy to see how these 40 particles, by their symmetrical union with each other, can form a tetrahedron, which Hauy conceives to be the primitive form of the integrant particle of alum. The octahedron is a much more probable primitive form. It might be conceived to be formed by the six integrant particles of sulphate of potash, and sulphate of alumina, and the thirty four particles of water, which are probably much smaller, may fill up the intervals between them. The objection to this supposition is, that in that case the atom of sulphate of potash cannot be surrounded by the atoms of sulphate of alumina, as one would naturally expect, from their mutual affinity for each other. The most probable supposition of the arrangement of the integrant particles of alum is, that the atom of sulphate of potash occupies the centre; that it is surrounded at equal distances by the five atoms of sulphate of alumina, each surrounded by seven atoms of water. But, we do not readily see how such an arrangement would either form a tetrahedron or octahedron. This symmetrical arrangement of the different integrant particles that compose a crystal, deserves to be studied with care, because it is probable, that it will throw light on the nature of *affinity*, and the way in which atoms combine together.

The word *alumen*, which we translate *alum*, occurs in Pliny's Natural History. In the 15th chapter of his 35th book, he gives us a detailed description of it. By comparing this with the account of στυπτηρια given by Dioscorides in the 123d chapter of his 5th book, it becomes quite obvious, that he alludes to the same substance. Hence it follows, that στυπτηρια is the Greek name for *alumen*. Pliny informs us, that alumen was found naturally in the earth. He calls it *salsugoterræ*. Different substances he informs us, were distinguished by the name of alumen; but they were all characterized by a certain degree of astringency, and were all employed in dyeing and in medicine. The light-coloured alumen was useful in brilliant dyes; the dark-coloured only in dyeing black, or very dark colours. One species of alumen was a liquid, which was apt to be adulterated; but, when pure, it had the property of striking a black with the juice of the pomegranate. This property seems to characterize a solution of sulphate of iron in water. It is quite obvious, that a solution of our alum would possess no such property. Pliny says, that there is another kind of alum which the Greeks call *schistos*. It forms in white threads upon the surface of certain stones. From the name, *schistos*, and the mode of formation, there can be little doubt, that this species was the salt which forms spontaneously on certain slaty minerals,—as alum slate and bituminous shale, and which consists chiefly of sulphate of iron and sulphate of alumina. Possibly in certain places the sulphate of iron may have been nearly wanting; and then the salt would be white, and would answer, as Pliny says it did, for dyeing bright colours. Several other species of alumen are described by Pliny, but we are unable to make out to what minerals he alludes.

The alumen of the ancients, then, was not the same with the alum of the moderns. It was most commonly a sulphate of iron, sometimes probably a sulphate of alumina, and usually a mixture of the two. But the ancients were unacquainted with our alum. They were acquainted with sulphate of iron in a crystallized state, and distinguished it by the names of *misy*, *sory*, *chalcanthum*, (*Plinii*, xxxiv. 12.) As alum or green vitriol were applied to a variety of purposes in common, and as both are distinguished by a sweetish and astringent taste, writers, even after the discovery of alum, do not seem to have discriminated the two salts accurately from each other. In the writings of the Alchemists we find the words *misy*, *sory*, *chalcanthum*, applied to the alum as well as sulphate of iron, and the name *atramentum sutorium*, which ought to belong (one would suppose) exclusively to green vitriol, applied indifferently to both.

When our alum was discovered is entirely unknown. Beckman devoted a good deal of time to trace the history of this salt, and published a curious dissertation on the subject. But his attempts to trace its origin were unsuccessful. The manufacture of it was discovered in the East; but at what time or place is totally unknown. It would appear, that, about four or five hundred years ago, there was a manufactory of it at Edessa in Syria, at that time called Rocca. Hence, it is supposed, the origin of the term *Rock alum*, commonly employed in Europe; though there are others that pretend that the term originated at Civita Vecchia, where alum is made from a yellow mineral in the state of a hard rock.

Different alum works existed in the neighbourhood of Constantinople. About the time of the fall of the Grecian empire, the art of making alum was transported into Italy, at that period the richest and most manufacturing country in Europe. Bartholomew Pernix, a Genoese merchant, discovered alum ore in the island of Ischia, about the year 1459. Nearly at the same time, John di Castro, who was well acquainted with the alum works in the neighbourhood of Constantinople, suspected that a mineral fit for yielding alum existed at Tolfa, because it was covered with the same trees that grew on the alum mineral near Constantinople. His conjecture was verified by trials, and the celebrated manufactory at Tolfa established. Another was begun in the neighbourhood of Genoa, and the manufactory flourished in different parts of Italy. To this country it was confined for the greatest part of a century. Various manufactories of it were established in Germany, by the year 1544. In the time of Agricola, there was a manufactory of it at Commoton in Bohemia. About the same time,

 an alum work was established near Carthagena in Spain, at Alcmaron.

England possessed no alum works till the reign of Charles I. Thomas Chaloner, Esq., son of Dr Chaloner, who had been tutor to Charles, while hunting on a common in Yorkshire, took notice of the soil and herbage, and tasted the water. He found them similar to what he had seen in Germany, where alum works were established. In consequence of this, he got a patent from Charles for an alum work. This manufactory was worth two thousand a-year, or perhaps more. But some of the Courtiers thinking this too much for him; prevailed with the King, notwithstanding the patent, to grant a moiety of it to another person. This was the reason why Mr Chaloner was such a partizan of the Parliament, and such an enemy of the King, that, at the end of the civil war, he was one of those who sat in judgment upon his Majesty and condemned him.* Since that time, various alum works have been established in different parts of England and Wales. But none at present exist, except the Whitby works, originally established by Mr Chaloner, and two works at the Hurlet and Campsie, both in the neighbourhood of Glasgow.

Several alum works likewise exist in Sweden, particularly in West Gothland. There is one for example at Hænsæter, near the borders of the Wene lake, on the west side of the mountain called Kinnekulle. But, for a description of the Swedish works, we refer to Bergman's *Opuscula*, Vol. I. p. 284, or the English translation, Vol. I. p. 342. We do not know if any alum works exist in Poland or Russia; but, as the greatest part of these extensive countries consists of alluvial soil to a great depth, it is probable, that little alum ore will be found in them.

Various minerals are employed in the manufacture of alum; but by far the most important of them are the following three: *alum stone, alum slate, bituminous shale.*

Alum stone is the mineral which occurs at Tolfa, near Rome, from which the celebrated Roman alum is made. Werner also possesses specimens of the same mineral from Hungary. At Tolfa, it is said to constitute a hill. Its colour is greyish white, sometimes yellowish grey, and sometimes, as Gay Lussac informs us (*Ann. de Chim.* LV. 267.) reddish from the peroxide of iron. It is massive and rather hard. It has no lustre. It is translucent on the edges. Fractures uneven, approaching to the fine earthy. Fragments blunt edged. Does not adhere to the tongue. It is rather heavy; but its specific gravity is not accurately known. This mineral, according to the analysis of Klaproth (Gehlen's *Neue Allgemeine Journal der Chemie*, VI. 35.) is composed of the following constituents:

| | |
|---|---|
| Silica - - - - | 56.5 |
| Alumina - - - | 19.0 |
| Sulphuric Acid - | 16.5 |
| Potash - - - - | 4.0 |
| Water - - - - | 3.0 |
| Loss - - - - | 1.0 |
| | 100.0 |

Vauquelin likewise analyzed this mineral, and found the same constituents, though in different proportions. We have no analysis of the varieties of alum stone which contain peroxide of iron. Thus it appears, that alum stone contains all the ingredients of alum ready formed.

Alum slate is a much more abundant mineral than alum stone. It is said to alternate with primitive clay slate. It occurs abundantly along with transition slate; and there can be little doubt that it occurs likewise in the flœtz formations. In West Gothland in Sweden, it constitutes a part of different hills; as Kinnekulle, Hunneberg, and Halleberg; in all of which it appears to alternate with flœtz trap rocks. It occurs likewise abundantly in Whitby in Yorkshire. We have never ourselves been upon the spot; but, from the general structure of Yorkshire, and the neighbouring counties, indeed of the whole east coast of England, there can be very little doubt that, in this position, it is also a flœtz rock.

Alum slate, as the name implies, is a slaty rock, though sometimes it occurs in balls. The colour is blueish-black, with a strong shade of grey. Fracture straight slaty. Fragments tabular. Its internal lustre is glimmering. It retains its colour in the streak; but acquires more lustre. Soft. Not particularly brittle. When exposed to the air it effloresces, and acquires an aluminous taste.

This mineral has never been accurately analyzed. But there can be no doubt that it contains silica, alumina, iron, sulphur, charcoal, and often likewise potash. Probably this was the mineral upon which the *alumen scissile* of the ancients was found.

Bituminous shale, the *brandschiefer* of the Germans, is a slaty mineral, which almost constantly accompanies beds of coal; and, accordingly, is very common in Great Britain. Its colour is brownish-black. Its fracture is thin slaty. Fragments tabular. Internal lustre glimmering; but the colour is not altered. Very soft. Rather sectile. Feels rather greasy. Easily frangible. When heated, it burns with a pale flame and sulphureous odour, and becomes white. It has never been accurately analyzed; but it is probably nothing more than slate clay, which occurs so abundantly in the independent coal formation, impregnated with the matter of coal. Its other principal constituents must be silica, alumina, and iron pyrites.

Slate clay itself, at least not sufficiently impregnated with coaly matter to deserve the name of bituminous shale, is frequently employed in the making of alum. This is the case in the neighbourhood of Glasgow.

Four different processes are employed by the alum manufacturers, according to the nature of the mineral from which the alum is to be extracted.

* *Letters written by Eminent Persons, in the Seventeenth and Eighteenth Centuries; and Lives of Eminent Men*, by John Aubrey, Esq.; Vol. II. p. 281.

The process employed at Tolfa is the simplest of all. If the Tolfa stone be kept constantly moistened with water for about two months, it falls to powder of itself, and yields alum by elixiviation. But this is not the process employed by the manufacturers. The alum stone is broken into small pieces, and piled on the top of a perforated dome, in which a wood fire is kindled. The smoke and flame of the wood penetrate through the pieces of alum stone, and a sulphureous odour is disengaged, owing to the decomposition of a portion of the sulphuric acid in the stone. This roasting is twice repeated; the pieces of ore which, the first time, were at the edge of the dome, being the second time put in the middle. The process of roasting this stone requires considerable attention. If the heat be too great, the quality of yielding alum is destroyed. If the heat be too small, the stone does not readily fall to powder. There can be little doubt that the unroasted stone would yield more alum than the roasted; but probably the additional labour requisite in the latter case would more than swallow up the increase of product.

The roasted stone, which has now acquired a reddish colour, is placed in rows between trenches filled with water. This liquid is so frequently sprinkled on it, that the stone is always moist. In two or three days it falls to powder, like slacked quicklime; but the daily watering is continued for a month. The success of this part of the operation is said to depend very much on the weather. When the weather is rainy, the alum is all washed out, and little or nothing left for the manufacturer to extract. In such cases, it is obvious that the alum stone should be covered by a shade from the rain.

When the stone has by this process been reduced to a sufficiently fine powder, it is thrown into a leaden boiler, filled two-thirds with water. During the boiling, the powder is frequently stirred up, and the water that evaporates is replaced. When the boiling has been continued for a sufficient time, the fire is withdrawn, and time allowed for the earthy matter to subside to the bottom. A cock is then opened, which allows the clear liquor to flow out into deep wooden square vessels, so made that they can be easily taken to pieces. Here the alum gradually crystallizes, and attaches itself to the sides and bottom of the vessel. The mother liquid is now drawn off into shallower wooden troughs, where more alum crystals are deposited. The liquid has now a red colour, and is muddy; and the last alum crystals are mixed with this red matter. They are washed clean in the mother liquor, which is finally pumped into a trough, and used in subsequent processes.

The alum obtained at Tolfa is the purest of all. It is known by the name of *Roman alum*, and is in very high estimation. It is always mixed with a little reddish powdery matter, which is easily separated from it. What this red matter is, has not been ascertained; but it is not peroxide of iron. To the eye it has very much the appearance of a vegetable matter. We have some notion that it is added artificially by the sellers of Roman alum. Probably Roman alum at first had a red tinge, in consequence of the red matter in the mother liquor remaining partially attached to it. The goodness of the alum may have given the purchasers a partiality to the red colour, and induced the sellers to add a red powder artificially. We have never had an opportunity ourselves of examining this matter; but have been informed by those that have, that it contains no iron.

It is not improbable that this process would be improved by grinding the Tolfa stone to a fine powder in a mill, without any previous roasting, and then keeping the powder moistened with water for a considerable time. If the residual earth, after the alum is extracted, be boiled with sulphuric acid, the liquid yields alum crystals by evaporation. This is a demonstration that neither the alumina nor the potash is exhausted, and that the sulphuric acid, driven off by the roasting, is so much alum lost to the manufacturer. Indeed, the quantity of sulphuric acid in the alum stone is not sufficient to occupy the whole of the potash in the formation of alum. It would be necessary to add about one-tenth of the weight of the alum stone of sulphuric acid, if it were wanted to employ the whole potash present in the stone. The consequence of this addition (supposing no loss) would be an additional quantity of alum, amounting to rather more than one-fifth of the weight of the alum stone employed.

Alum slate being very different in its composition, requires a different treatment to fit it for yielding alum. If the alum slate contain a notable quantity of lime or magnesia, it does not answer the purposes of the manufacturer so well. Indeed, the proportion of lime present may be conceived to be such, that no alum would be obtained whatever. As alum slate has never been subjected to accurate analysis, we do not know in what proportion these two earths exist in it, or whether they may not, in many cases, be absent altogether. The essential ingredients in alum slate for the alum-makers are alumina and iron pyrites.

The first process is to roast the ore. In Sweden, where the fuel is wood, and consequently expensive, it is customary to use the alum slate itself as fuel for roasting the ore. For this purpose, a small layer of brushwood is covered with pieces of alum slate, and set on fire; and, as the combustion proceeds, new layers of alum slate are added. It is usual to place alternate layers of roasted and unroasted alum slate. The combustion continues for a month or six weeks. At Whitby, coal is employed for roasting the alum slate. Indeed, the alum slate of Whitby is lighter coloured than that of Sweden, and probably would not burn of itself. So great is the quantity of combustible matter in the Swedish alum slate, that it is employed as fuel for burning limestone. Great quantities of limestone are burnt in this manner at Hunneberg, near the south side of the lake Wener. The roasted ore has usually a brown colour. When it is red, the quantity of alum which it yields is considerably diminished.

By this roasting the pyrites is decomposed. The sulphur is converted into sulphuric acid, while the iron is oxydized. In what manner this change is produced it is not easy to say. Indeed, it does not seem certain that pyrites is a constant ingredient in alum slate. We have never been able to detect any, by the eye, in any specimens of Whitby alum slate which we have examined. At Hænsæter in Sweden, no sulphate of iron crystallizes when the liquid is

evaporated; yet, if pyrites had been present, it is difficult to see any reason that should prevent this salt from being formed. Hence it is probable, that, in alum slate, the sulphur is sometimes at least combined with other substances than iron. It must always be in a state of combination; for, if it were in a loose state, it would be driven off by the roasting. This point deserves to be elucidated, by analyzing different varieties of alum slate.

The roasted ore has an astringent taste, owing to the sulphate of iron and sulphate of alumina which it contains. The next process is to lixiviate it with water, in order to dissolve out these salts. For this purpose, it is put into reservoirs made of wood or masonry, with a stop-cock at the bottom to draw off the water. The usual method is to keep the water for twelve hours in contact with ore that has been twice lixiviated; then to draw it off, and allow it to remain for an equal period on ore that has been once lixiviated. Lastly, it is run upon fresh ore, and allowed to remain on it for twelve hours longer. If the specific gravity of the liquid thus treated be 1.25, at the temperature of 55°, it may be considered as saturated with sulphate of alumina and sulphate of iron. But we presume that this specific gravity is not often obtained.

The liquid, thus impregnated with salt, is now boiled down in leaden vessels to the proper consistency for crystallization. In Sweden, the fuel employed for this purpose is alum slate. By this means, a double effect is produced. The liquid is evaporated, and the alum slate is roasted. During the boiling, abundance of oxide of iron falls mixed with gelenite, if lime be one of the constituents of the alum slate. When the liquid is sufficiently concentrated, it is let into a square reservoir, in order to crystallize. Great quantities of sulphate of iron crystals are usually deposited in this vessel. These are collected by drawing the liquid off into another reservoir. When all the sulphate of iron that can be obtained has been separated, a quantity of sulphate of potash, muriate of potash, or putrid urine, is mixed with the liquid. The sulphate of potash is procured from the sulphuric acid-makers, and the muriate of potash from the soap-makers. By this addition, alum is formed in the liquid, and it gradually deposites itself in crystals on the sides of the vessel. These crystals are collected, and dissolved in the smallest quantity of boiling water that will take them up. This solution is poured into large wooden casks. In a fortnight or three weeks the alum crystallizes, and covers the sides and bottom of the cask. The hoops are now taken off, and the staves of the cask removed. A mass of alum crystals, having the shape of the cask, remains. This mass is pierced, the mother liquor allowed to run out, and preserved for a subsequent process. The alum, being now broken in pieces, is fit for sale.

The manufacture of alum from bituminous shale, and slate clay, bears a considerable resemblance to the manufacture from alum slate; but differs in several particulars. There are two works of this kind in the neighbourhood of Glasgow, managed with great skill, and excellent in every respect. We shall give a sketch of the processes followed in these works. The bituminous shale and slate clay employed, are obtained from old coal pits, which are very extensive in the neighbourhood of Glasgow. The air in these coal-pits is moist, and its average temperature about 62°. The shale, having been exposed for many years, has gradually opened in the direction of its slaty fracture, so as to resemble in some respects a half-shut fan, and all the chinks in it are filled with a saline efflorescence in threads. This salt is white, with a shade of green; has a sweetish astringent taste, and consists of a mixture of sulphate of iron and sulphate of alumina. Nothing more is requisite than to lixiviate this shale with water, in order to obtain these salts in a state of solution. The lixiviated ore being left exposed to the weather, forms more salt, which is gradually washed out of it by the rain water, and this water is collected and preserved for use.

The next step in the process, is to boil down the liquid to a sufficient state of concentration. At Campsie, all these boilers are composed of stone, and the heat applied by means of steam. This is a great saving, as leaden vessels are not only much more expensive, but require more frequent renewal. When the liquid is raised to a sufficiently high temperature in the stone reservoir, pounded sulphate of potash, or muriate of potash, as they can be procured, is mixed with it, and there is an agitator in the vessel by which it is continually stirred about. This addition converts the sulphate of alumina into alum. The liquid is now let into another trough, and allowed to remain till it crystallizes. There are two salts contained in solution in this liquid, namely, sulphate of iron and alum; and it is an object of great consequence to separate them completely from each other. The principal secret consists in drawing off the mother liquor at the proper time; for the alum is much less soluble in water than the sulphate of iron, and therefore crystallizes first. The first crystals of alum formed, are very impure. They have a yellow colour, and seem to be partly impregnated with sulphate of iron. They are dissolved in hot water, and the solution poured into troughs, and allowed to crystallize a second time. These second crystals, though much purer, are not quite free from sulphate of iron; but the separation is accomplished by washing them repeatedly with cold water; for sulphate of iron is much more soluble in that liquid than alum. These second crystals are now dissolved in as small a quantity of hot water as possible, and the concentrated liquid poured while hot into large casks, the surface of which is covered with two cross beams. As the liquor cools, a vast number of alum crystals form on the sides and surface. The casks are allowed to remain, till the liquid within is supposed to be nearly of the temperature of the atmosphere. This, in winter, requires eleven days; in summer, fourteen or more. We have seen the liquid in a cask that had stood eleven days in summer, still more than blood-hot. The hoops are then removed, precisely as in the manufacture of alum from alum slate.

There always remains in the boilers a yellowish substance, consisting chiefly of peroxide of iron. This is exposed to a strong heat in a reverberatory furnace, and it becomes red. In this state it is washed, and yields more alum. The red residue is ground

to a fine powder and dried. It then answers all the purposes of Venetian red, as a pigment. By altering the temperature to which this matter is exposed, a yellow ochre is obtained instead of a red.

In France, where alum ores are by no means abundant, alum is manufactured from clay. This method of making the salt, was first put in practice by Chaptal, when Professor of chemistry at Montpellier. His methods have been since gradually improved, and brought to a state of considerable perfection. The first process tried was this: the clay was reduced to a fine powder in a mill, and then mixed with sulphuric acid. After remaining some days, it was exposed for twenty-four hours to a temperature of about 130°. It was then lixiviated, and the liquid mixed with urine or potash. This method being found inconvenient, was abandoned for the following: the clay being well ground, was mixed with half its weight of the saline residue, from a mixture of sulphur and nitre. This residue is little else than sulphate of potash. The mixture was formed into balls about five inches in diameter, which were calcined in a potter's furnace. They were then placed on the floor of a chamber, in which sulphuric acid was made. The acid vapour caused them to swell, and to open on all sides. In about a month, they were sufficiently penetrated with the acid. They were then exposed to the air, under shades, that the saturation might become more complete. Finally, they were lixiviated, and the liquid being evaporated, yielded pure alum.

This process has been considerably improved by Berard, the present proprietor of the Montpellier alum work. Instead of exposing the calcined balls to the fumes of sulphuric acid, he sprinkles them with a quantity of sulphuric acid of the specific gravity 1.367, equal to the weight of the clay employed. But it is obvious, that the proportion must vary with the nature of the clay. The solution takes place with the greatest facility, and crystals of alum are obtained by evaporating the liquid.

Another process was put in practice by Chaptal in the neighbourhood of Paris, and is still followed, or was at least followed some years ago by M. Bouvier. A mixture is made of 100 parts of clay, 50 parts of nitre, and 50 parts of sulphuric acid of the specific gravity 1.367; and this mixture is put into a retort, and distilled. Aquafortis comes over, and the residue in the retort being lixiviated with water, yields abundance of excellent alum.

We may mention another process described by Caraudan, and certainly practicable, and even easy, though we do not believe that it would be attended with profit. He forms 100 parts of clay into a paste with water, holding 5 parts of common salt in solution. This paste is formed into cakes, and calcined in a reverberatory furnace. The calcined mass is reduced to powder, and well mixed with the fourth part of its weight of concentrated sulphuric acid. When the muriatic acid vapours are dissipated, as much water is added as there had been employed of acid, and the mass is kneaded with care. A strong heat is produced; the composition swells; more water is added; and at last a solution of potash, in which the alkali amounts to one fourth of the acid employed. The liquor is now drawn off, and, on cooling, it yields a copious deposite of alum crystals.



In the preceding sketch of the manfacture of alum, no notice has been taken of alum earth as an alum ore, because the writer of this article has never had an opportunity of seeing any manufactory of the salt from this material. We conceive the process to be nearly the same as that followed, when bituminous shale or slate clay is the alum ore. Alum earth seems to be a vegetable substance, or rather to be derived from the vegetable kingdom. It is connected with coal, and may, without impropriety, be considered as a variety of brown coal. There is a manufacture of alum from this substance at Frienwalde, in Germany. Klaproth subjected this variety of alum earth to analysis, and from 1000 parts of it obtained the following constituents:

| | |
|---|---|
| Sulphur - - - - - | 28.5 |
| Charcoal - - - - | 196.5 |
| Alumina - - - - | 160.0 |
| Silica - - - - - - | 400.0 |
| Black oxide of iron - | 64.0 |
| Sulphate of iron - - | 18.0 |
| Gypsum - - - - - | 15.0 |
| Magnesia - - - - | 5.0 |
| Sulphate of potash - - | 15.0 |
| Muriate of potash - - | 5.0 |
| Water - - - - - | 107.5 |
| | 1014.5 |

The excess of one and a half *per cent.* obviously proceeded from the water adhering to the salts. (J.)

AMBOYNA. The reader will find some interesting particulars regarding the history of this celebrated island in the body of the work. Its great importance, as the centre of the *Clove-trade*, renders it necessary that we should here enter into some further details. It is divided into two unequal parts, by two deep bays, which are separated only by a narrow isthmus of one mile across. The bay on the west side extends to about two thirds of the length of the island, and forms a commodious and safe harbour. That on the east side is much smaller, and, as a harbour, very insecure, both on account of its bad anchorage, and of its rocky shores. The largest division is called Hitoo, and the smallest division Leytimoor. Although the larger bay is more commodious for a settlement, it is in the Leytimoor division that the Europeans have chosen to fix their residence; and they have here erected their principal fortification of Victoria, which is an irregular hexagon, with a ditch and covered way on the land side, and a horn-work towards the sea. Being commanded however by two ranges of heights, at the distance of from 700 to 1200 yards, it could make no serious resistance against an invading force. "The town of Amboyna is extremely clean, and both neatly and regularly built. The streets run at right angles, and the houses, on account of the frequency of earthquakes, are seldom above one storey high. From the covert way of the fort to the town, there is an esplanade of nearly 250 yards, terminated by a range of handsome dwelling-houses, with a double row of nutmeg-trees

Amboyna. in front of them. In these houses, the principal inhabitants reside. There are two well built churches in the towns established by the Dutch Government, one for the European, the other for the Malay Christians. All the other public buildings are in the fort, except the stadthouse, which fronts the esplanade, and is a neat building of two stories." *(Asiatic Annual Register for* 1800.)

Amboyna has long been the seat of the supreme government of the Spice Islands; and, under its jurisdiction are comprehended ten other islands; namely Ceram, which is equal in size to all the rest, Ceram Laut, Bouro, Amblaw, Manipa, Kelang, Bonoa, Harackau, Saparoua, and Noossa Laut. The cultivation of the nutmeg has been, for some years past, prohibited in Amboyna; the industry of its inhabitants being chiefly directed to the rearing of the clove-tree. It is only in Amboyna, and the three islands of Harackau, Saparoua, and Noossa Laut, that cloves are now cultivated.

"The clove-tree grows to the height of about forty or fifty feet, its branches spread, and its leaves are long and pointed. In a favourable soil, it begins to bear at fifteen years' growth, is in perfection at twenty, and continues to bear, without any apparent decay, till the age of forty or fifty. Some trees yield thirty pounds of cloves; but the average quantity produced, does not amount to more than six pounds a tree. They grow to the greatest perfection in deep vallies, well sheltered by hills and woods, and in a soil of a rich black mould, quite dry; though they require frequent rains for the greatest part of the year, and very hot weather at the gathering season; which commences generally about the latter end of October, or the beginning of November, and continues until February. In April and May, there is an after-crop, but of a very inferior quality." *(Asiatic Annual Register for* 1800.*)*

The Dutch East India Company appear to have been actuated by the same sordid, narrow, and oppressive views, which have, in a greater or less degree, characterized all the European governments established in the east. Cloves, the great article of produce throughout the island, are rigorously engrossed for the benefit of the Company. And for the convenience of this monopoly, the province, and its dependencies, is divided into several districts, over which residents or governors are appointed, for the purpose of preventing all contraband trade, and to take care also, that the whole produce of the country is strictly delivered up at a fixed price. The Governor has under his immediate management seven great, and twenty-four small districts; and the subordinate residents have committed to them from six to ten districts, with the exception of the resident of Saparoua, who has under his superintendence twenty-four districts. These districts are likewise called regencies; and the officers who govern them are distinguished by the names of Regents, Rajahs, Patties, and Orankaios. Several of these regencies are hereditary, and are enjoyed by the lineal descendents of the Portuguese families who first settled in the island. All the others are appointed by the Governor, although, in this respect, he is obliged to regulate his choice by the ancient customs and prejudices of the people, whose reverence for the ties of consanguinity Amboyna. carries them so far, as to induce them to keep a regular pedigree of their families, which is registered in the secretary's office, and on which the candidate for a vacant regency rests his primary claim. The regents are the vassals of the Company, who not only claim the sovereignty of the island, but the actual property of the soil; the whole of the lands being in their immediate possession, except a few pieces of ground belonging to burghers and private persons, who, under the prohibition of cultivating the clove-tree, are permitted to alienate them. A similar claim has been advanced by the English East India Company to all the lands of Bengal. But the justice of these claims is exceedingly doubtful; for it is certain that, before the English or Dutch visited India, the soil was possessed; and the question is, how the new claimants came to have a better title than the original proprietors? In Amboyna, however, though the Dutch Company claim a paramount right in the soil, they still so far acknowledge the rights of individuals to certain districts, that they do not attempt to deprive them of their property without compensation; especially if their lands produce clove-trees, which, being considered the peculiar inheritance of the planters, are held to be inviolable.

It is only in the districts marked out by the state, that the cultivation of cloves is permitted; and the grounds which are appropriated for this purpose, are portioned out to the inhabitants. These grounds are called *Daty-lands*; a regular register of the produce of them is kept; the clove-trees are numbered once a-year; and their qualities particularly noted. The entire produce of these trees the people are bound, under pain of death, to deliver annually into the Company's stores. Where clove-trees flourish spontaneously without the limits of the lands appointed for their cultivation, an account of them is immediately taken, and inserted in the register; and where young trees shoot up, they are immediately transplanted into *Daty-lands*, unless the number of trees in them is already sufficient.

To enforce the law for cutting down all the clove trees, which, from the spontaneous bounty of nature, may shoot up in different parts of the island, an annual circuit is made by the governor, accompanied by a detachment of troops, and such of the gentlemen of the settlement as he may appoint to accompany him. As this expedition is performed by water, it is escorted by a number of the regents of the districts in their barges, which they are obliged to equip at their own expence. The governor generally sets out in the middle of October, attended by all the residents of those districts under the immediate management of the supreme government. As he proceeds, he calls on the attendance of all the principal people of the district through which he passes. He makes the tour in this manner of his whole dominions, continuing to increase his train of attendants, until, having made the complete circuit of the island, he returns to his capital. His annual cavalcade is much complained of, on account of the numerous exactions to which it gives rise.

In gathering the cloves, each labourer brings the quantity which he gathers to a weigh-house, where the

name of the person, together with the quantity delivered, is regularly noted. But, unless the cloves are thoroughly dried, the full weight is not always admitted. There must be an allowance for wastage, which is entirely at the discretion of the receiving officer, and under this pretence the unprotected inhabitants are exposed to numerous frauds. The price at which cloves are received by the State is 4s. 8d. *per* pound. But this price is merely nominal, in consequence of large deductions being subsequently made on various accounts. Of these the principal is an allowance of 20 *per cent.* on the weight of the cloves, for the benefit of the governor, and the other servants of the Company; besides which, there are other deductions for the regent and chief magistrates of the district, and the labourer's wages are also paid out of the price allowed by the State. The annual produce of cloves is estimated at 600,000 lb., from which a deduction of one-fifth, or twenty *per cent.* amounts to 120,000 lb.; and the tribute thus levied is portioned out among the residents and members of the executive government, according to their respective ranks. The produce of cloves is apt to vary, however, according as the season is favourable or otherwise.

For six years, ending 1791, the average quantity of cloves imported into Holland amounted to 597,617 libs., and were sold for a sum equal to L. 155,129; besides which, considerable quantities are annually sent to various parts of India, Persia, Arabia, and China; the exact amount of which it is impossible to ascertain. When the island was taken possession of by the British in 1796, there were in store 515,940 libs. of cloves. The quantity imported by the English East India Company after the conquest of the island by Britain, was, in the years 1803, 1804, 1805, respectively, 49,441; 127,866; 179,507 libs, which were sold for L. 8,789; L. 19,994; L. 27,912.

The despotism under which this fine island is oppressed, is sufficiently implied in the monopoly of its produce for the state, and in the severe and sanguinary laws which are found necessary to prevent contraband trade. If the government were to deal fairly with its subjects, the temptation to resort to other countries with this produce would be much diminished; and, in proportion to the severity of the laws established against such an intercourse, we may, therefore, fairly estimate the extent of the fraud practised upon the inhabitants by their mercantile despots. Monopoly, besides being in itself an odious abuse, is an impure source from which other abuses naturally spring; and in Amboyna, accordingly, we find that, as the produce of the inhabitants is engrossed by the State at an undervalue, they are upon the same principle forced to purchase at prices proportionally exorbitant, whatever necessaries they may require. A lucrative trade of this nature is carried on by the residents of the respective provinces, as well as by the military officers at the outposts with the peasantry under their authority. They procure from the supply of stores which the Dutch company used to send annually from Batavia, such articles as the natives require, particularly blue cloth, which they oblige them to purchase at a price far above its value; and, in order to furnish them with the means of satisfying their wants, the residents lend them money at usurious interest; so that these people are reduced to the miserable alternative either of submitting to the grossest oppression and fraud, or of remaining destitute of those things which nature and custom unite to render necessary. The accumulated debt in which the peasantry are thus involved, is a never-failing instrument of bondage and oppression; as it places them entirely at the discretion of their task-masters, to whose bounty they are indebted for their miserable subsistence. An order in council was published by the Dutch government, some time before the island was conquered by the British, prohibiting the residents from stopping from the peasantry for debts due to themselves, more than two-thirds of the amount of their spice money. But, while the residents retain the extensive powers with which they are necessarily vested, in order to enforce the system of monopoly, the peasantry must be at their mercy; and in that case, the government being tyrannical in its principle, pretexts will never be wanting for evading the force of particular laws.

The maxims on which this country is governed are well explained in a Code of written regulations drawn up by order of the Dutch Company some years before the island came into the possession of the British. This Code, in place of containing mild and liberal regulations for the general improvement of the community, is filled with all the impolitic restrictions of avarice and despotism; the general tendency of which is, by bending down and oppressing the lower orders of the community, to strike at the root of national prosperity, and, finally, to impoverish and degrade the country. From a view of those regulations, it appears to have been the settled policy of the government of Amboyna for 150 years back, to discourage cultivation,—to check all attempts to establish manufactures,—and, in short, to suppress every improvement which might enable the inhabitants to supply their own wants, and might thus render them independent of the monopolies established by their rulers. In this they have been but too successful; and hence the people are fettered down in a state of the most wretched poverty and dependence,—destitute of the common necessaries of life, in consequence of their progressive advance in price; while, in the meantime, the wages of labour have been forcibly depressed, or rather indeed have been kept back from the labourer by fraud; he being bound to the state for a variety of severe duties and services, for which he receives no remuneration. In consequence of these oppressions, the inhabitants are poor and indolent. Agriculture has made no progress. Not more than one-tenth of the island is under cultivation, and it is therefore dependent on Java for supplies of cattle, and grain. The same causes which have discouraged the cultivation of land and the rearing of cattle, have prevented the improvement of manufactures, or of the mechanic arts; of which the inhabitants are so ignorant, that they do not even manufacture the coarse cloth of which they make their own wearing apparel; but are furnished with it from Java or Ben-

gal, and receive it in retail from the residents and men in office, at such prices as they choose to fix on it.

All the natural productions of this island are in like manner neglected by the policy of its rulers. It formerly produced indigo of the finest quality and colour. But the growth of this valuable commodity was discouraged by the Dutch, chiefly with a view of protecting the indigo trade carried on between the mother country and her colonies in the West Indies; and from a jealousy also, that the natives, by acquiring wealth, might be enabled to assert their independence. Sugar grows to great perfection; but its cultivation is discouraged. Coffee is produced in great plenty in different parts of the island; and, were the culture of it sufficiently attended to, it would be equal in quality to the first Mocha coffee. Wheat might be cultivated to great advantage on the beautiful heights contiguous to the town of Amboyna, the soil and climate being well adapted for it. Of maize there is already a great abundance; and the dry and mountain rice is known here; but they have been but little attended to. The bread-fruit tree grows spontaneously all over the island; but is only made use of by the lowest orders of the people. The cocoa tree also grows here; but the cultivation of it is almost entirely neglected. If the culture of vegetables were sufficiently attended to, this island would produce a great variety of the finest quality. All sorts of roots are produced in abundance, particularly yams and sweet potatoes; and the increased circulation of specie, since the island has been in possession of the English, has induced the farmers to bring ample and regular supplies to the market. There is also great variety of fruits, of the finest quality and flavour. The general appearance of the island is extremely beautiful and picturesque. Mountains everywhere covered with lofty woods in perpetual foliage, and valleys clothed in verdure, interspersed with hamlets, and enriched by cultivation, exhibit the most delightful variety that nature in those tropical regions is capable of producing.

Amboyna was captured by the British in 1796, and restored to the Dutch by the peace of Amiens. It was again taken possession of in 1810, and restored to its former owners by the treaty of Paris concluded in 1814. See *Asiatic Annual Register for* 1800, p. 200; and Mr Milburn's valuable work, entitled *Oriental Commerce*, Vol. II. p. 394. (o.)

# AMERICA.

IN the Encyclopædia, there will be found, in its proper place, a full account of the first discovery of this vast Continent, and of the history, manners and institutions of its native tribes. There, also, will be found, some general views of its physical geography, and of its natural history. In the present article, we propose to exhibit a rapid sketch of the progress which has been made towards its full discovery; confining ourselves, however, chiefly, to those more recent exploratory enterprizes, by which its geography has been in any material degree corrected or illustrated.

*Progress of Discovery on the American Coasts.*

I. The sensation excited throughout Europe by the original discovery of America, gave rise among the maritime states to such a spirit of adventure, that in the course of the two succeeding centuries, the eastern, and a considerable part of the western coast was surveyed with tolerable accuracy. But the spirit of enterprise, satisfied with such vast contributions to the stock of geographical knowledge, appears to have languished for a time; and the expeditions of different navigators, who had successfully explored the north west coast of America, were either but imperfectly remembered, or were discredited as fabulous; while, in the absence of any solid discovery, the attention of mankind was occupied with the theory of a great southern Continent, or with the impracticable scheme of a passage to India through some of the inlets on the American coast.

In pursuance of this last project, different expeditions were undertaken during the early part of the last century; and though they all failed as to their original object, they were nevertheless extremely useful, as they led to an accurate survey of the shores of the different bays and inlets, through which there was any possibility of finding this much desired passage. It was owing to views of this sort, that the shores of Hudson's bay were so completely explored; and it was to the same notion of finding out a north west passage to India, that we are indebted for the knowledge which we possess of Baffin's bay. It was partly also with a view to this object, that Mr Hearne was dispatched, in the year 1770, under the orders of the Hudson's Bay Company, into the interior of the country, for the purpose of penetrating by land to the Northern Ocean. Mr Hearne set out in December from Fort Prince of Wales, situate in north latitude 58° 50′; and, after passing in a north-west course through the various tribes, who, without any fixed habitations, spend their miserable lives roving over the dreary deserts and frozen lakes of this immense tract, first added to the known geography of the Globe by this adventurous traveller, he reached Coppermine river on the 13th of July. This river he pursued to its mouth, which he places in the 72° of latitude, and about 25° west longitude, from the Fort from which he took his departure. It was then the 18th of July; and he states, that he viewed the sea at the river's mouth, which was full of islands and shoals, and that, though the season was so far advanced, the ice was not yet broken up, but only thawed about three quarters of a mile from the coast, and a little way round the islands and shoals. The result of this journey determined the northern limits of the American Continent, and set for ever at rest the notion of any passage through the barrier of eternal ice which surrounds its shores.

It was for the purpose of exploring the north west

coast of America, in search of a passage which might communicate with Hudson's or Baffin's bay, that Captain Cook was dispatched on his third and last voyage, in the year 1776. Having touched at the Cape of Good Hope, and at the various islands situate in the great Southern Ocean, this celebrated navigator did not arrive on the coast of America, till the year 1778. He anchored in Nootka sound on the 29th March; but he was so thwarted by unfavourable winds, that, with the exception of a few projecting headlands and capes, he could obtain no accurate view of the coast, until he reached the latitude of 55° 20′. About the latitude of 58°, he discovered an inlet, called by him Cross Sound; which is the last inlet towards the north, on that great extent of broken coast commencing on the north west shores of the American Continent, with the strait, said to have been discovered by a Greek pilot named De Fuca, and of which the reality was long called in question by subsequent navigators.

From the 58th parallel, Cook made an accurate survey of the coast, having explored Prince William's Sound, and the inlet now distinguished by his own name, until he was satisfied that they could lead to no ulterior navigation. He thence coasted along the peninsula of Alaska, and passing through that archipelago which is known by the name of the Aleutian islands, and which has the appearance of being a prolongation of the two opposite Continents, he entered Beering's bason; and advancing to the straits which divide Asia and America, he ascertained with accuracy the relative limits of these two great divisions of the Globe. Coasting along the American shore, and incessantly struggling with shoals and floating mountains of ice, he advanced into the Arctic ocean, as far as the parallel of 70° 44′, which he reached on the 18th of August. Here his further progress was arrested by a plain of solid ice, which extended from shore to shore; and here, therefore, is the utmost limit of the navigable ocean, betwixt the Continents of America and Asia. It may be remarked, that between Europe and America, the ocean continues navigable to within a few minutes of the 81st parallel, which was the latitude reached by Captain Phipps, in the year 1773, when he attempted to penetrate in this direction towards the east.

It appears, from the researches made by Humboldt in New Mexico, that the north-west coast of America was, at an early period, visited by the Spanish navigators, as far as the 57th degree of north latitude. But the result of these expeditions was studiously concealed by the Spanish government; from an apprehension, that the other nations of Europe would be tempted to form establishments on that coast, and thus to encroach on the exclusive title claimed by Spain to its possession. But when it was found, that, notwithstanding the utmost caution of that power, the maritime states of Europe were proceeding to examine those hitherto unknown shores, various expeditions were fitted out after the year 1774, by the government of Spain for the same purpose. In the course of these expeditions, the Spanish navigators extended their survey from San Carlos de Monterrey, on the coast of California, as far as Cook's Inlet; but their researches, though they determined with great accuracy various insulated points, were very far from affording an exact geographical delineation of the American coast.



Beyond the 58th parallel, the discoveries of Captain Cook are blended with those of the Russians, who, from their vicinity to America, have been enabled in some degree to anticipate the visits of the other European states to the north western part of that continent. To him, however, still belongs the glory of having first ascertained the true bearings of this portion of America; of having determined the limits of the two Continents; and of having at length furnished a key to the interesting problem as to the original population of the New World, formerly the source of so many vain, though ingenious conjectures.

While Captain Cook was engaged in these researches on the north-west coast of America, his sailors availed themselves of the opportunity of entering into an intercourse with the natives; from whom they procured, for European articles of small value, a supply of skins of sea otters and other animals. These being carried to China, were sold at an exorbitant profit; and Captain King, who succeeded Captain Cook in the command of the expedition, was so struck with the favourable opening which appeared to present itself for establishing a lucrative commerce, that his account of the voyage contained the exposition of a plan for a regular trade between the north west coast of America and China. The merchants of Europe, America, and China, tempted by the prospect of enormous profits, were eager to enter into the proposed trade, and the hitherto unknown and uninviting shores of north west America, were now frequented by trading vessels from different quarters of the Globe. In the course of those commercial adventures, various important inlets were discovered in the American coasts, which had unaccountably escaped the researches of the different navigators by whom they had been visited. In consequence of these discoveries, the expectation of finding a north-west passage to India began to revive; and the expeditions of the Greek pilot De Fuca, and of the Spanish Admiral De Fuente, both of which had long been treated as fabulous, were again brought into some degree of repute. With the original accounts of De Fuca's and Fuente's voyages, the most romantic tales had been circulated respecting the extent of coast which they had discovered, and the abundance of gold, pearls, and precious stones to be found in those unknown countries. These embellishments were added, for the purpose, apparently, of amusing the credulity of the age, and of thus attracting a degree of consideration which the mere fact of the discovery of an unknown coast would have hardly secured. But as the tradition, in both cases, was accompanied with such obvious fictions, the reality of the voyages was disbelieved; and, indeed, the whole passed for a mere invention. The reader will find some curious details upon this subject, in the Introduction prefixed by Fleurieu to the account of Marchand's *Voyage round the World.*

Juan de Fuca, a Greek pilot of the island of Cephalonia, is said to have been dispatched, in 1592, by the Viceroy of Mexico, to examine the west coast of America, for an inlet which might lead to a communication with the Atlantic ocean. When he ar-

America. rived between the 47th and 48th parallels, the land extended to the north east, and presented a large opening, into which he entered, and continued sailing in it for twenty days. He frequently went on shore, where he met with the natives in great numbers, who were clothed in the skins of animals; and finally, the account stated that he reached the Atlantic ocean, and that he returned to Acapulco after an absence of two years, warmly soliciting to be rewarded for his pretended discovery.

The account of the voyage of Admiral de Fuente, which was undertaken in 1640, states, that, being on an expedition of discovery on the west coast of North America, he came, after a prosperous voyage, from the 26th to the 53d degree of latitude, where, having found an extremely broken coast, he sailed about 260 leagues in crooked channels, and amongst an extensive collection of islands, which he named the Archipelago of St Lazarus. Here, it is said, his ships boats always sailed a mile a-head, to reconnoitre the passage, which was full of shoals, rocks, and sands. The account, besides, contains various details in regard to an extensive inland navigation by means of lakes and rivers; and it is even asserted, that they met a vessel which had come in this way from Boston on the other side of the Continent; but M. Fleurieu contends, that this piece of fiction must have been a spurious addition to the original narrative, as it is explicitly stated in the concluding part of it, that no passage was found which communicates with the Atlantic ocean. If they had met with a vessel from Boston, this of course was a clear proof of the existence of a communication with that ocean.

Although the accounts of these two voyages have been generally regarded as mere fables, the features of this part of the American shore, as they were gradually discovered by the commercial navigators who visited it, from the year 1787, were found to coincide so remarkably with the previous representations contained in the narratives of De Fuca and Fuente, as to afford a strong presumption that they had actually navigated those coasts. It was ound, wherever the coast was explored, from about the 48th to nearly the 58th parallel, that it was broken by numerous inlets; and that it was in the latitude of 53, as Fuente had described it, a complete archipelago, full of bays, harbours, intricate channels, and islands. In like manner, one of the trading vessels which visited this coast in 1787, commanded by Captain Berkeley, discovered a large inlet or strait between the 47th and 48th parallels, which is the latitude assigned for De Fuca's inlet in the narrative of his voyage. The same strait was observed in the following year by Captain Duncan, who anchored also in several harbours on the east of Queen Charlotte's islands; and surveying all that portion of coast which lies between the 54th and 51st degrees, found one continued cluster of islands, with numerous bays and passages. In 1789, this coast was visited by Captain Meares, who discovered the strait, and, anchoring in it, sent forward his long boat to make observations. The boat, he observes, sailed near thirty leagues up the strait, and at that distance from the sea, it was about fifteen leagues broad, with a clear horizon stretching towards the east. The boat's crew were there attacked by the barbarous natives, who had entered into a scheme for robbing and murdering them. A desperate conflict ensued, in which Captain Meares's crew, having repulsed the attack, were glad to escape without attempting any farther examination of those inhospitable shores. In the course of this voyage, the account contained in the exploded narrative of De Fuca, as to the coast, and the inhabitants, was found to agree, in several minute circumstances, with the observations of Captain Meares. In particular, a great headland or island described by De Fuca, was recognized; as well as a high pinnacle rock, placed, as he stated it, in the entrance of the inlet. The inhabitants were also found clothed in furs and bears skins; and a remarkable custom related by De Fuca, of binding the children's heads between two boards when young, so as to give to them the form of a sugar loaf, was still observed by Captain Meares, to prevail generally among these savages. The latitude assigned to the inlet by De Fuca and Captain Meares, was not exactly the same; but, the difference was such, as may be easily accounted for by the comparatively imperfect instruments in use among the early navigators. In addition to the preceding information, it was stated by Captain Meares, that the American ship the Washington, Captain Gray, had completely explored this strait, and found that it inclosed a large part of the Continent, communicating at both extremities with the Pacific Ocean. In the chart annexed by Captain Meares to his work, the track of the Washington through this interior sea is even marked. It appears, however, that no such voyage was ever made, Captain Gray, though he examined De Fuca's inlet, having returned by the same channel through which he had entered, without finding its termination.

The discovery of a great inlet in this part of the American coast, to which no termination had yet been found, and which had escaped the researches both of Cook and of the Spanish navigators, gave rise to various speculations. Among others, it revived the exploded hope of an existing communication between the Atlantic and Pacific oceans. It was imagined, that this inland sea might be connected with some of the great lakes in the interior of North America; that, if no communication actually existed with Hudson's or Baffin's bay, it might not be found a very arduous task, by calling in art and industry to the aid of nature, to effect this great improvement; and at any rate, that the prospect of such an inland navigation as was now opened by the recent discoveries, must be of vast importance to the future commerce and civilization of the American Continent. To ascertain the precise extent of those discoveries, an expedition was fitted out by the British Government, and placed under the orders of Captain Vancouver, (who had sailed twice round the world with Cook); with instructions to survey the west coast of America, from the 30th degree of north latitude to Cook's river. He was particularly directed to examine all the inlets with which he found the coast indented, for the purpose of discovering whether any navigable communication existed with any of the great lakes in the interior; and with this view, Cook's river was

America.

also recommended to his careful observation, as it was conjectured, that it might take its rise in some of the inland lakes already known to the Canadian traders. Captain Vancouver set out on his voyage in the end of the year 1790, and, after visiting several of the islands in the Pacific Ocean, he arrived on the coast of America in 1792. Having surveyed the coast from Cape Mendocino, he entered De Fuca's inlet in latitude 48° 23′½, and continuing his course almost directly into the Continent, for nearly 100 miles, he observed that the strait turned to the north west and south east. The southerly branch was found to terminate after a winding course of about ninety miles, in lat. 47° 21′ N., long. E. 237° 6′, in low and apparently swampy land. The northerly branch was next surveyed by Captain Vancouver, in all its numerous inlets; and after running in a north west direction, generally parallel with the coast, it was found to terminate at length in the Pacific Ocean, in Queen Charlotte's sound, in N. lat. 51° 45′, long. 232, 1 E.; cutting off from the Continent that large island, since distinguished by the name of Quadra and Vancouver, the two navigators, the one belonging to Spain, the other to Britain, by whom it was first surveyed. The survey of this strait was conducted with singular perseverance through a course of most perilous navigation; occasioned by the numerous islands and sunken rocks, which in many parts interrupt the passage,—by the rapidity of the current from those interruptions,—and, finally, by the great depth of the channel, which frequently affords no anchorage. In many places, the strait is of an unfathomable depth; and where it was only two miles wide, no bottom was found with 110 fathoms of line. Proceeding northwards, Captain Vancouver completed, amid various perils and fatigues, his laborious survey of that great archipelago, which extends along the American coast, to nearly the 59th parallel, and ends with Cross sound. Every bay was diligently explored, and every inlet traced to its termination. Prince William's sound was next examined, and, lastly, Cook's river, or rather inlet. Captain Cook, when he was advancing into this inlet, found the water grow less salt the farther he penetrated, and he thence concluded it to be the outlet of a large river. Captain Vancouver entered the inlet with his vessel as far as it was navigable; and he afterwards advanced with his boats, until he found the eastern banks gradually unite with those on the western side, in N. lat. 61° 29′ E. long. 211° 17′. Thus terminated for ever the long cherished hope of a north west passage to India. Every bay and inlet on the north west coast of America has now been minutely examined; and it has been found, that the Continent, throughout its whole extent, interposes between the Atlantic and Pacific Oceans, and that beyond its northern limits, a frozen sea presents an impenetrable barrier of ice to the enterprises of navigation.

While Captain Vancouver was engaged in his survey of the American coast, an expedition was fitted out nearly about the same time from Acapulco, under the orders of Don Dionisio Galiano, and Don Cayetano Valdes, for the purpose of surveying De Fuca's inlet, which had already been entered and examined to a certain extent by the Spanish navigators. In the course of this voyage, the Spanish and English expeditions met. Their respective commanders made a mutual and unreserved communication of their discoveries; they assisted one another in their operations; and the best understanding possible subsisted between them till their separation. The charts drawn up in the course of these expeditions have been all published without reserve; and they contain a most correct delineation of the American coast, from the 45th degree of latitude to Cape Douglas, in the east of Cook's inlet, which, before this period, was but imperfectly known. The coast from the 58th parallel, having been in some parts visited much about the same time by the English, the Spaniards, and the Russians, the same place has frequently received a name from the navigators of each of these nations. From this circumstance some confusion is apt to arise. We are occasionally perplexed by the synonymous appellations of different navigators; and it is only by a minute comparison of their respective charts that this inconvenience can be obviated.

Progress of Discovery in the Interior of North America.

II. While, in the course of three centuries, from its first discovery, the seaward limits of the North American Continent have been thus accurately surveyed, the progress of discovery in the interior has necessarily been much slower. Although numerous perils, no doubt, beset the navigator of an unknown coast, the ocean still presents a more favourable scene of enterprise than the land. An insulated band of travellers, traversing the deserts of an unknown Continent, are exposed to so many causes of destruction from the climate, from fatigue, famine, or the hostility of barbarous tribes, that enterprises of this nature are more unpromising than maritime expeditions; and they have accordingly been less frequently undertaken. Since the first settlement, however, of the European colonists in America, population and improvement have been regularly advancing; and the European inhabitants, gradually extending themselves over a large tract of the country, have now penetrated, more especially in North America, to a great extent into the interior. The rapid increase of population naturally produces an anxiety to inquire into the state of the unexplored country, and to ascertain how far it is adapted to the purposes of civilized life. With this view, several important journies have of late been undertaken, under the orders of the American government; while, in other parts, individuals have been occasionally prompted by a spirit of adventurous curiosity, or the love of science, to penetrate the unfrequented deserts of the New World. Of these journies, with their geographical results, we shall endeavour to submit a short abstract to our readers.

The ardour with which the fur trade in Canada began to be prosecuted from about the year 1770, naturally induced the rival adventurers who were engaged in it to advance as far as possible into the interior parts of the country; and it is now affirmed, that their journies extend from Montreal, in a north-westerly direction, to the astonishing length of nearly 4000 miles. The superintendents, clerks, interpreters, canoemen, and Indians, by whom this trade is carried on, generally set out, to the number of about two thousand persons, from Montreal, in the beginning

of May, and arrive upon Lake Superior about the middle of June. After transacting their business at this station, the different detachments proceed into the interior, for the purpose of collecting furs from the Indian tribes, in exchange for European goods. In conducting this commerce, they pass along a vast succession of dreary lakes and dangerous rivers, interrupted by rapids and carrying-places, which stretch into the interior as far as Fort Chepewyan, on the banks of the Lake of the Hills. Mr Mackenzie, who belonged to the Canada Fur Company, and who, in the course of his commercial business, had been accustomed to encounter all the hardships of this interior navigation, was encouraged, by the experience and knowledge which he had acquired of the country, to undertake a journey across the Continent, with the hope of reaching the Pacific Ocean. He accordingly set out from Fort Chepewyan, on the Lake of the Hills, and passed down the Peace, or Slave River, to the great Slave Lake; the waters of which he found so much incumbered with ice, in the middle of June, that he was obliged to coast round it till he reached its main inlet, towards the north-west, in lat. 61° N. He embarked on this stream, of which, the course being at first westerly, he naturally conceived that it would lead to the Pacific Ocean. It afterwards turned, however, to the north-west, and finally took a northerly course, carrying him forward with a rapid current, not towards the Pacific, but towards the Frozen Ocean. He was warned of his approach to the sea by the action of the tide in the channel, and on the shores; and he was then in lat. 69° N., west long. 134; about 24 degrees to the westward of the point at which Mr Hearne arrived in 1771.

The result of this expedition sufficiently demonstrated to Mr Mackenzie, that the route to the Pacific must be sought further to the south; and, far from being discouraged by the fatigues and perils which he had encountered in his first journey, he resolved to ascend to the source of the Unijah, or Peace River, in the Rocky Mountains, from which it flows nearly in an easterly direction, joining Slave River, and finally entering Slave Lake from the south. That he might have the whole summer before him, Mr Mackenzie set out from Fort Chepewyan, in the month of October 1792, with the intention of wintering in the remotest establishment of the Company, and of beginning his journey from this advanced station, as early in the spring as the river was navigable. He spent the winter accordingly among a tribe of Chepewyan Indians, and set out upon his adventurous expedition on the 9th May 1793. He arrived, after many difficulties and dangers, at the source of the Unijah, in lat. 54° N. long. 121° W. on the 13th of June. Here he found that he was only a few miles from the Tacoutche or Columbia, which, taking a southerly course, falls into the Pacific, in 46° 10′ N. lat. He embarked on this stream, and experienced great difficulties at first, from rapids and falls; but, as the stream enlarged, the navigation became easier, and he followed the course of this river till the 24th of the month, when he was induced, by the information which he received from the natives, to leave it, and to proceed by land directly across the Continent to the sea. In the course of twelve days, during which he was exposed to a variety of fatigues and dangers, he reached another stream, of which the navigation was more practicable; and having procured a canoe, he arrived on the shores of the Pacific Ocean, about the 22d of July, in lat. 52° 21′ N., long. 128° 2′ W.; immediately to the southward of the islands which Vancouver has distinguished by the name of Princess Royal's Islands. Mr Mackenzie returned by the same route, and arrived safely at the point from which he set out, on the 24th August 1793.

The journies of Mr Mackenzie appear to have been conducted with singular perseverance and intrepidity; and they have thrown considerable light on the geography of North America. The countries, indeed, which he traversed, are inhabited by savage tribes, who possess no peculiarity in their character different from other savages; being chiefly occupied with the mere wants of animal life, and having little attention or curiosity to bestow on any thing else. They are fickle besides, and treacherous, but easily deterred from open violence. It was of importance, however, to determine, at particular points, the northern limits of the American Continent, and to mark the course of the rivers which flow through this dreary country into the Frozen Ocean; and the account of the river since known by the name of Mackenzie's River, is in this view a real accession to geography. It is pleasing also to observe the near approach of the sources of the Unijah, or Peace River (which is connected with that great succession of lakes and rivers, terminating in the St Lawrence), and the Tacoutche, or the Columbia, which flows into the Pacific Ocean. In the present desolate state of this part of the American Continent, the vicinity of the various streams which flow in opposite directions into the Atlantic and Pacific, from that great dividing ridge of mountains which intersects the interior almost to the Frozen Ocean, can be of little moment; but, in a different stage of its progress, when these dreary abodes, at present the haunts of savages or of beasts of prey, are filled with industrious inhabitants, the facilities of inland communication which the country derives from the convenient distribution of its lakes and rivers, must be of vast importance to its future improvement.

The expeditions of discovery into the interior of North America, undertaken by order of the government of the United States, have been productive of much interesting information. These are, first, the journey of Major Pike, with a small detachment of troops, to the source of the Mississipi; second, his journey into the interior of Louisiana, for the purpose of exploring the course of several of its subordinate streams; and, third, the remarkable journey of Captains Lewis and Clarke to the source of the Missouri, and afterwards across the Rocky Mountains to the mouth of the Columbia, which flows into the Pacific Ocean.

The source of the Mississipi, and the country through which it takes its course, were but imperfectly known before they were visited by Major Pike. This enterprising officer left Fort St Louis, near the

America. junction of the Missouri with the Mississipi, on the 9th August 1805, and was nearly nine months in performing his interesting journey; during which, he laid down, with the greatest accuracy, the course of the Mississipi. He examined its banks, and collected information respecting the barbarous tribes who inhabit the adjacent country. The Mississipi, it appears, is divided near its source into two branches, one of which loses itself in Leech Lake, while the other, which may be termed the upper source of the river, takes its rise in Upper Red Cedar Lake, of which the lat. is 47° 42′ 40″ N. From this point, the distance to some of the head waters, which fall into Hudson's bay, is only about two leagues; the waters of the American continent being, in this manner here, as in other places, admirably disposed for interior navigation and commerce. The Mississipi generally flows from N. W. to S. W., and from its source to its mouth, in the Gulf of Mexico, is estimated to run a course of 2000 miles.

The second expedition of Major Pike was undertaken in the years 1806 and 1807; and was directed into the interior of Louisiana, with a view of examining the course of the various rivers which take their rise in the Rocky Mountains, and, running nearly westward, either fall into the Missouri from the south, before its confluence with the Mississipi, or into the Mississipi, after the two rivers are joined. Within this space four capital streams flow into these rivers; namely, the Kanses and the Osage, which join the Missouri, and the Arkansaw and the Red River, which flow into the Mississipi. The course of these rivers was but very imperfectly known until of late years, when they were surveyed by different parties of discovery, sent out by the Spanish or American governments. Several rivers were seen, indeed, to rise in the Rocky Mountains, which, it was nearly certain, must fall into the Missouri or the Mississipi; and as these last rivers were, in like manner, known to receive several large streams, it was naturally conjectured, that they were the same of which the source had been discovered at so vast a distance in the Rocky Mountains. Humboldt, accordingly, concluded that the river which rises to the north-east of the village of Taos, and which receives the Rio Mora from the vicinity of Santa Fe, is the same river which, in Louisiana, is called the Red River; and recent investigations have proved his conjecture to be right. In the course of Major Pike's expedition, in which the whole party had nearly perished from cold and famine, the Osage river was first surveyed, and was found to run a course of 1500 miles before its junction with the Missouri. The party next proceeded by land across the country to the Arkansaw, which they traced to its source; from which this great river, taking its windings into the account, was estimated, before it joins the Mississipi, to run the enormous length of 2173 miles. During the whole of this space, it may be navigated with boats properly constructed for the purpose, except for about 200 miles after it enters into the mountains. It receives, also, several small rivers, which are navigable for upwards of a hundred miles. From the Arkansaw, the exploring party proceeded northwards, and discovered the sources of America. two streams, which they conjectured to be the head waters of the Plate and the Yellow-stone rivers. Great light has been thrown on the geography of this part of the country, by the journey of Lewis and Clarke, and from their researches, Major Pike's conjecture as to the Plate appears to have been right; but he has mistaken a subordinate branch of the Yellow-stone River, called by Lewis and Clarke Beghorn river, for the principal stream. Major Pike returning, and proceeding to the south, struck into another stream, which he supposed to be the Red River. But he was met by a party of Spanish troops, who informed him that it was the Rio del Norte; and, being on the Spanish territory, he was made prisoner with his whole party, and carried into New Mexico.

The course held by Major Pike never brought him near the Red River. This river, however, had been previously examined in 1804, in the lower part of its course, to its confluence with the Mississipi, by Mr Dunbar and Dr Hunter, who were employed for this purpose by the government of the United States; while it had been explored from its source downwards, for about 230 leagues, by a large body of Spanish cavalry, who set out on this expedition from Santa Fe, in 1806. The course of this river, taking in all its irregular windings, cannot, according to recent observation, be estimated at less than 2000 miles. By the researches of these travellers, we have thus obtained a sufficiently accurate view of the course of the various streams which intersect this part of the American Continent; and it will be found, that all these rivers are so disposed, as greatly to facilitate the progress of cultivation and improvement. The countries visited by the exploring party of Major Pike, were inhabited by savage tribes, who subsist almost entirely by hunting; and the abundance of wild animals of every description to be found in those parts, affords ample encouragement to this mode of life. The borders of the Arkansaw he calls the terrestrial paradise of the wandering savage, on account of the immense herds there to be found, of buffalo, elk, and deer. The antelope is also common; and of the carnivorous animals, the wolf and bear are the most remarkable.

While the interior of Louisiana was, in this manner, so successfully examined, and the course of the various tributary rivers, which either flow into the lower Missouri or Mississipi, was so accurately determined; Captains Lewis and Clarke were entrusted by the American government with the still more important task of exploring the main stream of the Missouri, from its confluence with the Mississipi, to its source; and of afterwards proceeding across the Rocky Mountains to the first navigable river they should meet with, which they were to descend until they should arrive at the Pacific Ocean. They set out with an intrepid band of forty-five followers, mostly American soldiers, from the point of junction between the Missouri and Mississipi, in May 1804; and by the beginning of November, they had nearly ascended about half the course

America. of the river, in a direction almost north. They were now in the 47th degree of north latitude, and as the river had begun to be filled with floating. ice, they took up their winter abode in this station. In the meantime, the cold continued to increase, and the thermometer frequently stood at 52 degrees, and fell even as low as 74 degrees below the freezing point; at which time the cold was so intense that the sentinel who kept guard was forced to be relieved every half hour. The air was also filled with icy particles, which were so thick as to render the weather hazy, and to exhibit the appearance of two suns reflecting one another. The latitude to which the party had arrived, which was only 47 degrees north, will not account, even on the American Continent, for this extreme rigour of the climate. It is probably owing, therefore, in some degree, to the elevation of the ground; which, however, as Captains Lewis and Clarke's party were not provided with a barometer, was not ascertained with any precision. But the velocity with which the stream of the Missouri descends, amounting, according to a calculation by the log, generally to five miles per hour, and in some places to nearly double this rate, marks a great declivity of ground; and as the travellers had been gradually ascending from the time they had left the confluence of the two rivers, it is obvious, that, before they had arrived at their winter-quarters, they must have reached a point of the American continent of considerable elevation; and that this, combined with other causes, must have produced the extreme rigour of the climate.

Captains Lewis and Clarke left their wintering ground about the beginning of April, and proceeded in their hazardous enterprise. As they ascended the river, they found their course was mostly west, and afterwards south for a great length. The current was also less rapid, and the navigation more safe and easy, so that they advanced at the rate of about eighteen or twenty miles a-day. The country is described on both sides of the Missouri, after ascending the adjacent hills, as one fertile unbroken plain; extending as far as the eye can reach, without even a solitary tree or shrub, except in moist situations, or in the steep declivities of the hills, which afford shelter from the fires kindled by the savage inhabitants. On the sides of the hills, and even on the banks of the rivers, as well as on the sand-bars, a white substance was found, in considerable quantities, on the surface of the earth, which tasted like a mixture of common salt with Glauber salts. Many of the streams which came from the hills were so strongly impregnated with this substance, that the water had an unpleasant taste, and a purgative effect. The mineral appearances of coal and sulphur, with burnt hill and pumice stone, were also visible; and they found a bituminous water, with the taste of Glauber salts, and a tincture of alum. These appearances continued as they advanced. The salts were so abundant, that, in many places, the ground looked perfectly white. Pumice stones were observed floating down the river, and the coal appeared of a better quality, affording, when burnt, a hot and lasting fire, and emitting very little smoke or flame. Higher up the river, the bed of coal runs in some places six feet thick; and where wood is not plentiful, the abundance of this species of fuel must be of essential importance towards the colonization of the country. The adjacent hills exhibited also, as they advanced, large irregular masses of rocks and stones; some of which, although two hundred feet above the river, seem to have been once subject to its influence, being apparently worn smooth by the agitation of the water. These rocks and stones consist of white and grey granite; a brittle black rock; flint, limestone, freestone; some small specimens of an excellent pebble; and occasionally broken strata of a black-coloured stone, like petrified wood, which makes good whetstones. The country in the neighbourhood abounds with deer, elk, beaver, buffaloes, antelopes, and their followers the wolves, who make great ravages among them. Here also were met the brown and white bear, which were both found to be exceedingly ferocious. With these animals the party had frequent encounters; and though they were all well armed, and expert marksmen, they were often in great danger from this formidable enemy.

Advancing towards the Rocky Mountains, they found the river divided into two branches, and they were much at a loss which to pursue. At length they chose the branch that came from the south; and having ascended for some time, their ears were saluted with a tremendous noise occasioned by the great falls of the Missouri, and which, from the information of the Indians, they knew to be a certain mark that they were on the main stream. Higher up the river, they found it divided into three branches, which they distinguished by the names of the three leading statesmen in America, viz. Jefferson, Gallatin, and Maddison. They ascended the first of these streams, with a view of reaching, by the nearest course across the mountains, some of the smaller branches which join the Columbia, and lead to the Pacific Ocean.

It being necessary to obtain some knowledge of the country through which they were to direct their perilous course, Captain Lewis set out, accompanied by one of the most expert hunters, and two soldiers, along the Jefferson; and having advanced until the river had become so small that they could step across it, they ascended a high ridge towards the west, which forms the dividing ridge between the waters of the Atlantic and Pacific Oceans. Here they began to descend; and they reached a stream of clear water running to the west, which they rightly conjectured must belong to the waters of the Columbia. After various difficulties and uncertainties, they met with an Indian tribe, whom they fortunately persuaded to return with them to their companions at the source of the Missouri. By this tribe they were directed into the proper road across the mountains, which was to the north-west, the course of the Missouri having carried them considerably to the south of the head waters of the Columbia. In travelling this road, they encountered innumerable hardships from famine, occasioned by the scarcity of game, and the great cold in those higher regions, to which they had now penetrated. This part of their journey lasted about seven weeks, from the 18th August to the 7th October; at which period they em-

America.

barked in canoes built by themselves on the river Kooskooske. This river they found to be much embarrassed by a succession of dangerous rapids and shoals. These difficulties, however, they encountered with all the alacrity of men accustomed to danger; and, after a hazardous navigation, they descended into Lewis's river, and, sailing down this stream, they reached the Columbia, about 400 miles from its mouth. They came within sight of the ocean about the 7th November, when they were deluged for a time with almost perpetual rains. At this station they remained for the winter, which, as usually happens on the western coast of America, was extremely mild. As soon as the weather permitted, they set out on their return; and having, with great difficulty, succeeded in crossing the ridge of the Rocky Mountains, they arrived at Fort Lewis, on the Mississipi, on the 23d September; having, in the course of this remarkable journey, travelled over a space of about 9000 miles. The countries bordering on the Missouri they found inhabited by barbarous tribes, who subsist chiefly by the chace, few or none of them looking to agriculture as any resource. On the western side of the Rocky Mountains, the rivers yielded vast quantities of salmon; and such was the abundance of this fish in the Columbia, that they were caught in any quantity with little trouble. Here the inhabitants draw their chief subsistence from the rivers; and in many parts the salmon were seen, after being cured in a particular manner, built up in large stacks, as a provision for future consumption.

The expedition of Captains Lewis and Clarke, whether we consider the singular perseverance, courage, and address, with which it was conducted, or the important information to which it has led, may be undoubtedly regarded as one of the most memorable exploratory enterprises of which any nation has to boast. The chart which they have laid down of the course of the Missouri, with its subordinate streams, has filled up an immense chasm in the geography of North America, which may now be considered as complete in all its great features; namely, the direction of its mountains, and the course of its chief rivers. The researches of future travellers must therefore be limited to the subordinate task of filling up the details of the picture, of which the general outline has been already so boldly and successfully sketched. This, however, must be the work of time. At present, our knowledge of the interior of North America seems to be sufficient for every useful purpose; and it is only when population and improvement have made greater progress, that a more exact survey of the country will be required.

**Progress of Discovery in the Interior of South America.**

III. In South America, although the country may be said to be merely skirted with an exterior border of cultivation and improvement, the interior has been explored with considerable success. The immense rivers, with the innumerable tributary streams, which flow through the country in all directions, afford great facilities for traversing those vast regions; and it is no doubt in a great measure to this inland navigation that we are indebted for the geographical knowledge which we possess, imperfect as it is, of this portion of the American Continent. In Africa, a difference of climate, and a difference also in the configuration of ground, has given rise to a different disposition of its rivers. The Nile holds its solitary course through parched and burning deserts, where no rain ever falls, and where, for more than a thousand miles, not a single stream arises to pour its waters into the main channel. The water, on the contrary, which falls on the American Continent, seeks its way to the ocean through many different channels; and all the great rivers, until they fall into the ocean, are joined, in their course, by a variety of capital streams; all of which, communicating either by means of the main channel, or by its tributary waters, with a vast space of inland country, diffuse throughout the Continent all the advantages of a maritime boundary, and afford facilities for exploring the interior, which could not otherwise exist.

The Spaniards, ever since their first settlement in America, have been chiefly intent on the aggrandizement of their power and influence, and on the extension of their authority as widely as possible among the native tribes. For this purpose, they seem occasionally to have employed persuasion and address, and, at other times, to have had recourse to violence. In the latter case, troops were employed to take possession of a certain district; a particular space was then assigned for the villages of the native inhabitants, to which it was understood they were afterwards to be confined. Here they were gradually subjected to a system of magistracy and police, and they were afterwards reduced under a mild species of servitude, for the benefit of their conquerors. In general, the Indians were forced tamely to submit to this injustice; but, in some cases, they rather chose, after a violent struggle, to retire into the interior; from whence, under the influence of a just resentment against their oppressors, they continued to make incursions into the Spanish territories. The frontier which divides those hostile classes of inhabitants is in this manner the scene of a constant and inveterate war; and the Europeans are only secured against the irruption of the native tribes, by the imposing aspect of a strong military force.

Against this system of conquest the ecclesiastics always remonstrated, with laudable and becoming zeal; and they have uniformly recommended, that the improvement of the native Americans should rather be attempted by policy than by arms. Their humane counsels have so far prevailed, that, in later times, the Spaniards, in their attempts to civilize the native Indians, seem to have trusted almost entirely to conciliation. Missions or settlements have been established in different parts under the authority of ecclesiastics, and a few soldiers have generally accompanied the infant colony, to repel aggression, but not to offer violence. They to whom the administration of these settlements is committed, are directed to gain over the Indians by gentle means to habits of civilization,—to make distributions among them of provisions, iron, or of such implements of industry as may enable them to better their condition,—and gradually to inure them to the restraints, by making them duly sensible of the various advantages, of social life. It is also accounted of great

importance, that they should be converted to the Christian faith at the same time that they are instructed in all useful and necessary arts. How far this system, so full of enlightened humanity, is likely to succeed on any great scale, is a question of some difficulty. Azara, in his instructive account of the Spanish settlements in Paraguay, depreciates the services of the ecclesiastics in that part of the Continent. The Indians are so inveterately attached to their habits of barbarism, that force, he seems to think, is absolutely necessary to bring them under the yoke of civilization. It is seldom, he insists, that the savage has any attention to bestow on futurity. He is generally swayed by present objects; and hence the superior advantages of civilization, though they are continually displayed before him, have no effect in withdrawing him from the habits of his wandering and unsettled life. This is no doubt true; and it proves the difficulty, but certainly not the impossibility, of succeeding in the benevolent task undertaken by the Spanish missionaries. There is a very striking account, in the narrative of Vancouver's voyages, of the state of the Spanish missions on the coast of California; and the fine picture which is there exhibited of the reverence and attachment of the Indian population to their pastor, and of his unbounded ascendancy over them, evinces such a spirit of docility and affection in this simple people, as plainly shews that, under a wise system of management, they are capable of civilization; and that, though the existing generation were to remain in their original barbarism, the rising generation at least might be trained to agriculture, and to those other arts by which life is supplied with its most necessary comforts. We cannot, indeed, readily admit, that injustice is in any case the most perfect instrument of policy, or that there is no other way of guiding and controlling the human mind but by violence and cruelty.

With a view of extending civilization among the native tribes, various expeditions have from time to time been undertaken into the interior by the Spanish missionaries. Of these the latest and most remarkable appear to be, *first*, the voyage of Father Sobriela on the river Guallaga; and, *second*, the voyages of Father Girval on the great river Amazons.

Beyond the easternmost of the three ridges of Andes, which run in a direction nearly north and south, through the province of Peru, immense plains stretch out, to the extent of nearly 8000 square leagues, and so level, that they have been compared to the ocean. They lie between the river Ucayale and the Guallaga, which bound them to the east and west, while to the north they are bounded by the river Amazons. These vast plains, which have been denominated by the missionaries *Pampas del Sacramento*, are shaded with forests of eternal verdure, which form a delicious perspective; they contain also abundance of lakes and rivers, the isles and borders of which are inhabited by tribes greatly diversified in their manners and habits. Rain and thunder are frequent, and for some hours of the day thick fogs always rest on the tall trees. The thickness of the woods prevents the rain from penetrating, and the warmth and moisture give birth to innumerable insects and reptiles. Many of the rarest vegetable products are found in those regions: balsams, oils, gums, resins, incense, cinnamon,—superior in strength to that of Ceylon, but not so valuable, on account of a disagreeable juice which it transudes;—cocoa, cascarilla, and excellent spiceries are abundant. But, notwithstanding its valuable produce, and the inviting aspect of its evergreen forests, the warmth and humidity of the climate render the country so unhealthy, that few among the native tribes are said to live beyond fifty years of age. This vast region was first discovered about the year 1726; and several missions appear to have been established, all of which were, however, afterwards abandoned. As this territory was considered by the Spanish government to be of extreme importance, Father Sobriela was dispatched in 1790 to explore the course of the river Guallaga, its western boundary. This river rises in south latitude 10° 57′, and, after a course of about 400 miles, falls into the Amazons. He set out in July for the city of Guanuco, near the source of the Guallaga, where he spent some time in visiting the Indians; to whom, along with his spiritual doctrines, he gave lessons in agriculture, and the necessary implements of iron, by which those lessons were to be reduced to practice. Having embarked on the Guallaga, he descended the stream, and safely passed several rapids. At the rapid of Aguirre the chains of mountains join on either side, and form the *Ponguillo*;—a term borrowed from the language of Peru, signifying a door; and which is generally applied to those narrow and tremendous outlets where the rivers burst from the mountains. This passage forms a sort of gate, where the traveller passes as it were from one world into another, the whole aspect of nature having undergone a complete change; vast plains clothed with eternal verdure, and extending as far as the eye can reach, now succeeding to the lofty summits of the Andes lost in the clouds, and buried in perpetual snow. After passing the mountains, the Guallaga begins to spread, and rolls its majestic stream along the plain, which is now so large as to be navigable both day and night; while its banks, covered with lofty palms, and trees of every leaf, are enlivened by numerous birds of the richest plumage, and most diversified song. The scene is rendered still more interesting by the prospect of numerous trading canoes sailing up and down the river; while the crews of others are employed in gathering the cocoa-nuts produced in those immense forests, or the honey made by diminutive bees, which lodge their treasure in hollow trunks. The banks of the Guallaga are infested by innumerable swarms of mosquitoes, by which the inhabitants are cruelly tormented; and by that still more formidable animal the cayman or alligator, which grows here to an enormous size, and is seen lurking about in search of its prey. Father Sobriela, having passed the missionary village of Yurimaguas (where he saw the Indian method of catching the tiger or *jaugar*, in a kind of trap formed of stakes), arrived at Laguna, the capital of the province of Maynas, situate in 5° 14′ south latitude, on a lake, which, by a narrow channel, enters the Guallaga from the east. This settlement is not above thirty miles from

the confluence of the Guallaga with the main channel of the Amazons. It is the residence of the President of the missions, who is assisted by a Lieutenant-governor. The number of Christians is 8895, with nineteen Curates, and a Superior of the missions. Great care is taken to train the Indians to industry and to habits of morality; and the benevolent efforts of the ecclesiastics have so far succeeded, that the natives unite, with their ordinary employments of hunting and fishing, the cultivation of little fields of rice and sugar-canes. The villages of this province trade with each other, and with Quito, and Lamas, in salted fish, chocolate, wax, and vegetable candles, being the fruit of a tree, which, when lighted, presents both wax and wick; and the reformation which has been thus brought about in the habits of the native tribes, must be chiefly ascribed to the address, prudence, and indefatigable zeal of the Spanish missionaries, and to the benevolent principles upon which they proceed.

In 1791 the viceroy of Peru received an order to extend and secure the labours of the missionaries; and Father Girval was in consequence instructed to survey the great river Ucayale, which falls into the Amazons from the south, and which may be considered indeed as the main stream, as its course is longer, and as it also contains a larger body of water. In the course of three successive voyages, undertaken in 1791 and 1794, this enterprizing missionary ascended the Ucayale, which he explored to its confluence with the Pachitea. Having two canoes with fourteen Omaguan Indians, robust and dexterous rowers, he made great progress, frequently meeting with fleets of canoes filled with the natives, whom he always contrived either to soothe or to escape. The Guallaga and the Ucayale, which bound on the west and east the immense plains known under the name of *Pampas del Sacramento*, hold a parallel course at the distance of between 300 or 400 miles, until they fall into the Amazons; and it was an object of Father Girval's expedition, to discover whether there existed any navigable streams by which a communication might be opened across the country between these two rivers. After sixteen days navigation, he reached the Manoa, which falls into the Ucayale from the west; and, notwithstanding the rapidity of its stream, he proceeded to ascend it, expecting that it might either conduct him to the Guallaga, or to some of its tributary streams. Being obliged, however, to proceed partly by land, he found the road exceedingly difficult and dangerous on account of the precipices and thick woods; and having discovered a large river, which he supposed to be the Guallaga, but which afterwards proved to be the Manoa, the river he had previously ascended, he returned to the Ucayale; and, embarking on its stream, he arrived on the Amazons, and, ascending this river, he reached the mission of the Maynas on the Guallaga, after an absence of four months.

Father Girval proceeded on his second voyage in 1791. He entered the Ucayale on the 14th November, unaccompanied by any soldier or white person. The natives received him with great cordiality, though he was afraid of encountering the Casibos on the eastern shore, reputed the most ferocious tribe in those regions. But those whom he chiefly met in this part of the river, belonged to the tribe of the Conibos, who are more peaceable and humane, and, who generally, with their rude flutes, make signals of hospitality and peace. They navigate the river in large canoes, from sixteen to twenty yards in length, which they will employ a whole year in hollowing out of a single tree. This they accomplish by means of sharp stones and fire. The canoes of the Paros, another tribe of native Indians, afterwards began to make their appearance; and father Girval proceeded up the river, accompanied by a bark and sixty canoes of friendly savages. Arrived at the river Manoa, he immediately began, in consequence of the orders of the viceroy, to inquire for the beautiful bird called the Carbuncle, which is said to be about half a yard in height, of a most exquisite plumage, while its breast is also finely spotted. He was informed, that it was known to the Piro tribe, who inhabit the upper banks of the Ucayale. The next object of inquiry was, whether any of the tributary streams of the Guallaga and the Ucayale, approached so near each other as to facilitate the communication between the principal streams; and this point, so important to the future civilization of the country, was established by this second journey of father Girval. It was found that, from the Manoa, which enters the Ucayale from the west, the distance to the Chipurana, which enters the Guallaga from the east, is not great. A party of ten men and two women, being accordingly dispatched in this direction, reached the head waters of the Chipurana, after dragging their canoes over the land, which is here a beautiful plain, only one day; and embarking on this stream, they soon entered the Guallaga, which they descended to its junction with the Amazons, after a journey of fifteen days.

In a subsequent voyage, undertaken in the year 1794, father Girval ascended the Ucayale for about 600 miles, to its junction with the Pachitea. He found the river flowing in a gentle current, and abounding with fish, while animals of chace swarmed upon its shores. The savage tribes were generally pacific, and seemed to speak different dialects of the same language. Besides hunting and fishing, they cultivate a few herbs, particularly the *Yuca*, from which they extract an intoxicating drink; they also gather cotton, which serves them for the slight clothing which they wear, and they use axes of copper. They seem to be very dextrous at extracting an active poison from noxious plants; and so great is their confidence in the deadly power which it gives to their arms, that they will awake the fury, and await the attack of the fiercest tiger. They laugh when he prepares to spring, and, aiming at him the fatal shaft, the arrow flies, and he is dead. War is their ruling passion, and they are almost continually engaged in hostility with the neighbouring tribes.

The interior navigable communications which have been disclosed by the journies of those adventurous missionaries, may be of considerable importance to the commerce of South America. The sources of the Rio Guallaga, are not above two or three days' journey from Lima, which may thus open an intercourse, not only with the whole in-

terior of the country, but even with Europe. The productions of Peru may be carried down the great rivers Ucayale or the Guallaga, to the mouth of the Amazons, and from thence to Europe, in the space of five or six weeks; while it would require four months to reach the same point by doubling Cape Horn. But where the waters of an immense Continent, in their course to the sea, pass through the territories of different nations, political arrangements are frequently necessary to secure the advantages of nature. The Amazons, for about one thousand miles of its course, is in the power of the Portuguese; and Portugal has refused to the Spaniards the free navigation of this important river; although the cultivation of those extensive regions, situated on the eastern declivity of the Andes, and the prosperity of their inhabitants, depend, in a great measure, on the possession of this valuable privilege. It is to be hoped, however, that more liberal views will prevail; and that, in the present era of increasing improvement, the Portuguese government will not persist in imposing such a pernicious and useless restriction on the commerce of a great Continent.

The latest, and by far the most interesting journey, which has been undertaken into the interior of America, is that of Baron de Humboldt, a Prussian gentleman; who having, by a long course of study, instructed himself in all those important branches of knowledge, both moral and physical, necessary to form an accomplished traveller, set out, under the impulse of his own ardent genius, and love of science, to explore the wonders which nature has so profusely displayed in the interesting regions of the new world. He was accompanied by M. Bonpland, who, to indefatigable zeal, joined extensive acquisitions in science; and those two travellers arrived, in July 1799, at the port of Cumana, in South America. They employed the remainder of the year in visiting the coasts of Paria, the missions of the Indian Chaymas, the province of New Andalusia (a country liable to the most frightful earthquakes, and of which the climate, though the hottest, is perhaps one of the most salubrious in the world), New Barcelona, Venezuela, and Spanish Guiana. In the beginning of the year 1800, leaving the Caraccas, they went to visit the beautiful vallies of Aragua; and, proceeding southwards from Porto Cabello, they crossed the immense plains of Caloboza, the Apure, and the Orinoco. They next traversed the *Llanos*, a desert similar to those in Africa, wholly without vegetation, and where, by the operation of a vertical sun upon the sand, the horizon everywhere exhibits the well-known illusion of the distant sea. The country is here such an uniform level, that, for a space of 2000 square leagues, the inequality of the ground does not exceed five inches. The heat is excessive; the thermometer, in the shade, rising by the reverberation of the sun's rays, to 110 and 115 degrees of Fahrenheit's scale. The parched earth conceals crocodiles and serpents, which lie in a state of torpor, till they are called into life and activity by the periodical torrents which, for a time, deluge those barren regions. Humboldt and his companion travelled whole days in this pathless expanse, without meeting with a single shrub, or with one solitary dwelling, to refresh the eye. At St Fernando d'Apure, they commenced a most fatiguing navigation of 1000 marine leagues, which they performed in canoes, laying down an accurate chart of the country through which they proceeded. They descended the stream of the Apure, which falls into the Orinoco, at the 7th degree of latitude; and, remounting the last river, they reached the confluence of the Guaviari, after passing the celebrated cataracts of Mapures and Atures. They afterwards ascended several rivers of inferior note; and from the mission of Sarita, they travelled over-land to the sources of the Rio Negro; which Condamine saw at its point of junction with the Amazons, and which he denominates a sea of smooth water. About thirty Indians carried their canoes through lofty forests, to the creek of Pemichin. By this rivulet, they entered the Rio Negro, which they descended to Fort-Charles. From this station, ascending the river Cassiquiari, they reached the Orinoco; and from thence they proceeded to the volcano of Daida, and to the mission of Esmeralda, near the sources of the last mentioned river. These sources they were prevented from reaching by the Guaicas, a pigmy race, of a fair complexion, but exceedingly warlike and ferocious. From the mission of Esmeralda, Humboldt and his companion descended the Orinoco to its mouth; and, in the course of this painful navigation, they were exposed to sufferings of every sort. They were in want both of food and shelter; and, during the night, they were exposed to the periodical rains, which fell in torrents. If they went a-shore to seek shelter or subsistence in the woods, they were tormented by the muskitoes, and by other loathsome insects; if they ventured to bathe their parched limbs in the stream, they were in danger of being devoured by the crocodile; or of being attacked by a small species of voracious crab; and, in addition to all these evils, they were exposed to the unhealthy exhalations of a moist climate under a burning sun.

Having escaped these various dangers, they returned to Cumana, where, after remaining for some months, they set sail for Cuba; and returning from this island to Carthagena, they successively visited the cities of Quito, Santa Fe, Lima, Guayaquil; and, proceeding to the province of New Mexico, they staid in that country for about a year; from whence they returned to France, by the way of North America.

Those illustrious travellers have been since engaged in communicating to the world the result of their inquiries, which are of such extent, that they embrace every object connected either with nature or with society. The works which they have already published abound in the most valuable details, relative to the political institutions of the country, the manners of the people, and the state of the economical arts; while they contain besides much curious information, of great importance to general science. Of these various and interesting details, we shall endeavour to present our readers with an abstract, under the articles to which they more particularly relate; and, in the meantime, it may be added, that the researches of Humboldt have tended to correct many prevailing errors in the geography of America; as he has accurately fixed the position of nearly

three hundred capital points in the Spanish settlements. He has besides ascertained, in the most satisfactory manner, that the river Cassiquiari, which falls into the Orinoco, is also connected, by means of the Rio Negro, with the great river Amazons; and it thus appears, that the more attentively we investigate the geography of the American Continent, we find it the more admirably provided by the number, and still more by the distribution of its rivers, with the means of extensive navigation and commerce.

See Hakluyt's *Collection of Voyages*. Cook's *Voyages*. Vancouver's *Voyage*. Meares's *Voyage*. The learned *Introduction* by Fleurieu to Marchand's *Voyage*. Mackenzie's *Travels in North America*. Pike's *Journey to the Source of the Mississipi*. Lewis and Clarke's *Travels to the Pacific Ocean*. De Pons, *Voyage à la Partie Orientale de la Terre Ferme*. Azara, *Voyage dans l'Amérique Meridionale*. Account of "recent discoveries in South America," in Pinkerton's *Geography*, 3d edition. M. Humboldt has as yet published only part (two volumes) of his *Personal Narrative;* but the reader will find a sketch of his expedition by Dr Kesteloot, annexed to the *Discours sur les progrès des Sciences, ou compte rendu par l'Inst. de France à l'Empereur*, published in Holland in 1809; and there is a similar sketch in the admirable account of his *Tableau Physique des Regions Equatoriales*, in the 16th volume of the *Edinburgh Review*. We have everywhere sought in vain for the Spanish Collection by Estalla, entitled *Viagero Universal*, which extends to 44 vols. 8vo; and which appears, from Mr Pinkerton's references, to contain much valuable geographical information in regard to America. (o.)

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AMERICA, UNITED STATES OF. A view of the recent history of these Republics, of their statisties, and political relations, shall be given under the head UNITED STATES.

AMES (FISHER), a native of the United States, was born April 9, 1758, at Dedham, a small town about nine miles south of Boston. His father, Dr Nathaniel Ames, who practised as a physician in Bridgewater, died in 1764, leaving his mother with four sons and one daughter. Of these Fisher was the youngest; and though his mother was left in narrow circumstances, she determined to educate him with the utmost care. He accordingly began the study of Latin when he was six years of age, and in July 1770, soon after he was twelve years old, he was admitted to Harvard College; previous to which, he was examined by a gentleman accustomed to teach the languages, who expressed surprise at his uncommon quickness and accuracy. At the university, the singular modesty and mildness of his character, joined to the pleasantness and vivacity of his manners, endeared him both to his companions and to his instructors. He was scrupulous in his attention to his studies, and equally so in the choice of his associates; by which means he soon acquired the character of shining parts, and of unblemished morals.

Among the students who attended this seminary, a society was formed for speculative discussion, and Mr Ames here first displayed his talents for extemporaneous eloquence. But though he was resolved to embrace the profession of the law, several years passed away before he entered on a course of professional study. During this period, he appears to have maintained himself chiefly by teaching a school; and his intervals of leisure were filled up by a diligent perusal of the works of classical writers, both ancient and modern.

He at length commenced his professional career at Dedham, his native place, in the year 1781; and he soon began to be distinguished by his eloquence as a pleader. At this time, however, his attention was attracted to public events, which began to be unusually interesting, and to threaten the rupture which afterwards took place between the colonies and the mother country. Mr Ames espoused the cause of the former, and though he was not of an age at the commencement of the contest to take any active part, he watched its progress with all the anxiety of a genuine patriot. In the course of this eventful struggle, the provisional rulers of America were greatly distressed for the means of paying the troops, and of defraying the other necessary expences of the state; and they were therefore induced to have recourse to the most exceptionable expedients. Among these, the issue of a depreciated paper currency formed a standing resource, and this measure was also accompanied by an arbitrary regulation of prices. Of all these projects Mr Ames was a zealous opposer. At a meeting of a Convention of Delegates assembled at Concord, he pointed out the certain mischiefs which would result from attempts of this nature; expatiating, in strong terms, on the futility and injustice of endeavouring to regulate by force the value of that which must be fixed in the market by the voluntary consent of the buyer and the seller.

In the convention for ratifying the federal constitution in 1788, Mr Ames acted a conspicuous part. He was chosen the same year a member of the House of Representatives, and for eight years he continued a firm supporter of Washington's administration. In the contests occasioned in Europe by the progress of the French revolution, he appears to have been a keen partisan of the powers combined against France; and in the controversy which took place between Britain and America, respecting the privilege of the neutral powers during war, he espoused the cause of the belligerent; pleading warmly for the exercise of the maritime rights of Britain in their fullest extent. In his zealous hostility against France, he advised his countrymen, both in his political speeches and writings, to submit to all the restrictions imposed by this country on the commerce of the neutral powers.

In the year 1796, he retired from public business


From Arrowsmith.

Engraved by S. Hall, 14 Bury Str. Bloomsb.


From Arrowsmith.

Engraved by S.y Hall, 14, Bury Str. Bloomsbury.

*Published by A. Constable & C.o Edinburgh, 1816.*

in consequence of his declining health; but he still continued a diligent writer of political essays. The purpose of these publications was generally to support the declining cause of the federalists,—to vindicate the policy of Britain,—and to awaken the jealousy of his countrymen against the hostile and ambitious views of France. His health, however, which had been on the decline since the year 1795, was now broken, and though he was chosen president of Harvard college, he was obliged to decline the office. He continued for two years in a state of extreme debility, and on the 4th July 1804 he expired. When intelligence reached Boston of his death, a meeting of the citizens took place to testify their respect for his services and character, and at their request, his remains were brought to the capital for interment.

In America, the literary character of Fisher Ames appears to be held in high estimation; and some of his countrymen have even been absurd enough to compare him to Burke. We perused his essays with a curiosity greatly excited by so ambitious a comparison; but without being able to discover one trait of resemblance to that great master of political philosophy and eloquent composition;—without perceiving any thing much above mediocrity, either in thought or expression;—and with frequent feelings of tedium and disgust, excited by abortive strainings after imagery and eloquence. Having said thus much, we think it but right to add the opinion delivered by perhaps the ablest American writer of the present day, "that Ames, both as an orator and an author, would have reflected lustre on any country; and may be considered as the most perfect model for youthful emulation, which the United States have produced." *American Review*, Vol. I. p. 89.

His works, with an account of his life, were published in an octavo volume, at Boston, in 1809; and the writer to whom we have just alluded pronounces this volume, "not only a treasure of political wisdom, but a literary monument, which every American should contemplate with gratitude and patriotic pride." (o.)

AMMAN (John Conrad), a Physician, and one of the earliest writers on the instruction of the *deaf and dumb*, was born at Schaffhausen, but in what year is uncertain. In 1687, he graduated at Basle; and, his religious principles not permitting him to settle in his native country, he retired to Holland, where he appears to have devoted his time and attention chiefly to the cure of the defects and imperfections of speech. He first called the attention of the public to his method, in a paper which was inserted in the *Philosophical Transactions;* and which appeared in a separate form in the year 1692, under the title, *Surdus Loquens, sive Methodus qua qui surdus natus est loqui possit;* and afterwards, with much additional matter, in 1702 and 1728, under the title, *Dissertatio de Loquela, qua non solum vox humana, et loquendi artificium ex originibus suis eruuntur, sed et traduntur media, quibus ii qui ab incunabulis* SURDI ET MUTI *fuerunt, loquelam adipisci, quique difficulter loquuntur, vitia sua emendari possunt.* In this work, which Haller terms "*vere aureum*," he developes, with great ability, the mechanism of language, and describes the process which he employed in teaching its use to the unfortunate class of persons committed to his care. This consisted principally in exciting the attention of his pupils to the motions of his lips and larynx while he spoke; and then inducing them, by gentle means, to imitate these movements, till he brought them to repeat distinctly letters, syllables, and words. As his method was excellent, we may readily give him credit for the success to which he lays claim. In a long course of practice, he says that he never failed in his endeavours but in two instances; one of which was that of a girl who was an idiot, and the other that of a Jew, from whose father he foresaw that he would not get any thanks for his trouble. The edition of Cælius Aurelianus, which was undertaken by the Wetstens in 1709, and which still ranks as one of the best editions of that author, was superintended by Amman. (E.)

AMMAN (Paul), a Physician and Botanist, was born at Breslau in 1634. In 1662, he received the degree of Doctor of Medicine from the University of Leipsic, and, in 1664, was admitted a member of the Society *Naturæ Curiosorum*, under the name of *Dryander.* Shortly afterwards, he was chosen Extraordinary Professor of Medicine in the above-mentioned University; and, in 1674, he was promoted to the Botanical Chair, which he again, in 1682, exchanged for the Physiological. He died in 1691. Paul Amman seems to have been a man of an acute mind, and extensive learning; but a restless and irritable disposition led him to engage too much in controversy, and to indulge in a degree of raillery in his writings, which the nature of the subjects hardly warranted. By his first work, which was published in 1670, under the title, *Medicina Critica, seu Centuria Casuum in Facultate Lipsiensi resolutorum variis discursibus aucta*, he drew down upon himself the displeasure of the Faculty, who had certainly no cause to rejoice at this exposure of their decisions. In the *Paracænesis ad discentes circa institutionum medicarum emendationem occupata*, which appeared three years afterwards, and in the *Irenicum Numæ Pompilii cum Hippocrate,* which he published in 1689, he showed his independent turn of thinking, by boldly attacking the systems of Galen and Hippocrates, and the abuses to which the implicit adoption of them had given rise. But it is chiefly on his botanical writings that his fame ought to rest. The *Suppellex Botanica, et Manuductio ad Materiam Medicam*, which he committed to the press in 1675, contains a full, but somewhat prolix, catalogue of the plants of the botanic garden of Leipsic and its environs, with their synonyms; followed by a brief introduction to the study of the Materia Medica, which proves an accurate knowledge of the science he was then employed in teaching. His next publication was entitled, *Character Plantarum Naturalis, ab ultimo fine, viz. fructificatione desumptus, et in gratiam philatrorum per canones et exempla digestus;* to the second edition of which, in 1685, he prefixed a dissertation on the true classification of plants. In this work he adopted the arrangement of Morison, endeavouring to show, as the title imports, that the genera of plants were only to

be distinguished by their parts of fructification, and illustrating his method by the description of 1476 different genera and species, in alphabetical order. An enlarged edition of this book was published by Daniel Nebel, in 1700, with the addition of the characters of Tournefort and Hermann. For the complete list of Paul Amman's writings, see Haller, *Bibl. Med.* and Eloy, *Dict. Hist.* (E.)

AMMONIAC, Sal, a saline substance, formerly much used in dyeing, and some other arts. At present, not much of it is employed in this country, most of the sal-ammoniac manufactured in Great Britain being sent to Russia.

Sal-ammoniac is usually in the form of a hard white cake, opaque or only slightly translucent. Its taste is cooling, saline, and rather disagreeable; though it has been occasionally employed as a seasoner of food. Its specific gravity is 1.441, according to the mean of the experiments of Wallerius, Watson, and Kirwan. It requires rather more than three times its weight of cold water to dissolve it. By proper evaporation, the sal-ammoniac may be obtained in crystals. The primitive form of these crystals, according to Hauy, is the octahedron; but most frequently they appear in the state of long four-sided pyramids, or of thin plates, like sword blades. It often assumes the form of plumose crystals, consisting of long hexahedral pyramids attached to a stem. These crystals contain a little water, and therefore dissolve in somewhat less than three times their weight of cold water. A hundred parts of alcohol, of the specific gravity 0.834, dissolve $1\frac{1}{2}$ parts of this salt.

When exposed to a moist atmosphere, it gradually absorbs water and deliquesces, though very slowly. When heated, it sublimes unaltered in a white smoke, having a peculiar smell, very characteristic of sal-ammoniac. If a cold body be presented to this smoke, the sal-ammoniac condenses on it, and forms a white crust. When thus sublimed, it has the property of carrying along with it various bodies, which, when heated by themselves, are perfectly fixed. Thus, if it be mixed with gold leaf, filings of iron, or oxide of copper, these substances rise along with it, and tinge the sal-ammoniac purple, yellow, or red.

If quicklime or potash be triturated with sal-ammoniac, a strong smell of ammonia exhales. If sulphuric acid be poured upon it, vapours of muriatic acid are separated in abundance. If equal bulks of muriatic acid gas, and ammoniacal gas be brought into contact, they immediately combine and condense into sal-ammoniac. These facts, which are well known, show us, that sal-ammoniac is a salt composed of muriatic acid and ammonia. The composition of this salt seems to have been first discovered by Tournefort in 1700. The experiments of Geoffroy junior in 1716, and 1723, were still more decisive, and those of Duhamel, in 1735, left no doubt upon the subject. Various experiments have been made by modern chemists, to determine the proportion of the constituents of this salt. But its analysis is attended with peculiar difficulties, on account of the volatility of the sal-ammoniac, and the want of a simple method of determining the proportion of ammonia. Dr Thomson first pointed out a process by synthesis, which has the advantage of being very simple, and at the same time rigidly accurate. He observed, that when muriatic gas, and ammoniacal gas, both as dry as possible, are brought in contact with each other, they always combine in equal volumes. Therefore, sal-ammoniac is composed of 100 measures of muriatic acid gas, united with 100 measures of ammoniacal gas. Now, 100 cubic inches of muriatic acid weigh 38.979 grains, and 100 cubic inches of ammoniacal gas weigh 18 grains. Hence, sal-ammoniac is composed of

| | | |
|---|---|---|
| Muriatic acid | - | 38.979 |
| Ammonia | - - | 18.000 |
| | | 56.979 |

Or of

| | | | | |
|---|---|---|---|---|
| Muriatic acid | - | 68.41 | - | 100 |
| Ammonia | - - | 31.59 | - | 46.178 |
| | | 100.00 | | |

This gives us the exact proportions of the acid and base. But, at present, we are not in possession of any exact method of determining the quantity of water which the salt contains. From the property which the salt has of deliquescing in a moist air, it is obvious, that the affinity of water must be considerable. Hence, it is probable, that the quantity of water in this salt is pretty great.

An integrant particle of muriatic acid weighs 4.762, and an integrant particle of ammonia 2.149. Hence, it is obvious, that sal-ammoniac is composed of one integrant particle of muriatic acid, united to one integrant particle of ammonia.

But there is another way in which the composition of this salt may be viewed. Muriatic acid is a compound of chlorine and hydrogen. It has been shown, that most of the substances hitherto called *muriates* are in fact *chlorides*, or combinations of chlorine, with the metallic bases of the alkalies, earths, or metallic oxides respectively. Thus, *common salt* is a *chloride of sodium*, or a compound of chlorine and sodium; *horn silver* is a *chloride of silver*, or a compound of chlorine and silver. Now, of all the bases capable of combining with acids, amounting to fifty at least, every one is known to contain oxygen except ammonia. It would be singular if such a solitary exception were to exist. Hence, analogy is in favour of the supposition that ammonia contains oxygen. If a hole be dug in a piece of sal-ammoniac; if this hole be slightly moistened by breathing on it; if a globule of mercury be put into it, and this globule be subjected to the action of a tolerably powerful galvanic battery, the mercury speedily acquires the consistence of butter, and swells up so, as to amount to nearly four times its original bulk. In short, it is converted into an amalgam. Ammonia itself may be substituted for sal-ammoniac; but the experiment, in that case, is attended with greater difficulty. In this case, the ammonia is evidently decomposed by the galvanic energy, and one of its constituents has combined with the mercury, and converted it into an amalgam. If the amalgam be put under water, it is speedily reduced to the state of pure mercury, while, in the meantime, ammonia and hydrogen gas

are evolved. The same thing happens, if the amalgam be put into a glass tube without any water.

Now, no instance can be produced of any substance uniting with mercury, and forming an amalgam which retains the metallic lustre, except a metal. Hence, we are entitled to infer, that the mercury in the preceding experiment has united with a metal, and that the base of ammonia is therefore a metal. Gay-Lussac and Thenard have endeavoured to show, that the amalgam is a compound of hydrogen and mercury. Supposing their experiments correct, the inference would be, that hydrogen in a concrete state is a metal, and that azote, the other constituent of ammonia, is a compound of hydrogen and oxygen. But, whatever shall be the fate of these inferences, it seems reasonable to conclude, from the preceding experiment, that ammonia is a compound of oxygen, and an unknown metallic basis, to which the name of *ammonium* has been given.

Now, supposing this conclusion correct, is it not probable that sal-ammoniac, like the other supposed muriates, is in reality a chloride? This supposition is much strengthened, by comparing sal-ammoniac with the other salts having a base of ammonia. Sulphate of ammonia, sulphite of ammonia, nitrate of ammonia, and, in short, the whole class of ammoniacal salts, are decomposed when exposed to heat. But sal-ammoniac is sublimed unaltered. This difficult decomposition characterizes all the chlorides. But if sal-ammoniac be a chloride, it is obvious, that the hydrogen in the muriatic acid must find a quantity of oxygen in the ammonia, just capable of saturating it, and converting it into water. But 100 muriatic acid contain 2.86 hydrogen, which requires $21\frac{2}{3}$ of oxygen to convert them into water. Therefore, 46.178 ammonia contain $21\frac{2}{3}$ oxygen. Of consequence, ammonia is composed of

| | | |
|---|---|---|
| Ammonium - | 24.511 or | 100 |
| Oxygen - - | 21.666 | 88.39 |
| | 46.177 | |

and chloride of ammonium, or pure sal-ammoniac, is a compound of 97.14 chlorine + 24.511 ammonium, or of one atom of chlorine, and one atom of ammonium.

If this analysis of sal-ammoniac be correct, as we think it is, it follows that this salt, when purest and driest, contains one integrant particle of chloride of ammonium, and thirty-seven integrant particles of water. Or, that it is composed by weight of

| | |
|---|---|
| Chloride of ammonium - | 75.07 |
| Water - - - - - - | 24.93 |
| | 100.00 |

But if the smallest quantity of water which sal-ammoniac, made from perfectly dry muriatic acid gas and ammoniacal gas, can contain, be almost one fourth of its weight, the inconclusiveness of the experiments of Bostock, Trail, and Murray, respecting the possibility of extricating water from sal-ammoniac, made by uniting these two gases, becomes too evident to require any refutation.



The name *sal-ammoniacus* occurs in Pliny. (Lib. xxxi. cap. vii.) He tells us, that it was applied to a kind of fossil-salt found below the sand, in a district of Cyrenaica, from which circumstance its name was derived. It was similar in appearance to the *alumen scissile*, had a disagreeable taste, but was useful in medicine. The general opinion is, that the sal-ammoniac of the ancients was the same as that of the moderns; but the imperfect description of Pliny is far from being sufficient to decide the point. The native sal-ammoniac of Bucharia, as described by Model and Karsten, and which was analyzed by Klaproth, has no resemblance to the salt described by Pliny. The same remark applies to the sal-ammoniac of volcanoes. Dioscorides, in mentioning sal-ammoniac, (Book v. chap. cxxvi.) makes use of a phrase quite irreconcilable with the description of Pliny, and rather applicable to rock-salt, than to our sal-ammoniac. Sal-ammoniac, he says, is peculiarly prized, if it can be easily split into rectangular fragments. Finally, we have no proof whatever, that sal-ammoniac occurs at present, either near the temple of Jupiter Ammon, or in any part of Cyrenaica. These circumstances induce us to conclude, that the term sal-ammoniac was applied as indefinitely by the ancients, as most of their other chemical words. It may have been given to the same salt, which is known to the moderns by that appellation, but was not confined to it.

The name "sal-ammoniac" is derived, according to some, from the temple of Jupiter Ammon, in the neighbourhood of which it was found; according to others, from a district of Cyrenaica called *Ammonia;* but, according to Pliny, from the sand in which it occured,—the Greek name for sand being ἀμμος.

But whether our sal-ammoniac was known to the ancients or not, there can be no doubt that it was well known to the Alchemists. Albertus Magnus, in his treatise *De Alchymia*, informs us, that there were two kinds of sal-ammoniac, a natural and an artificial. The natural was sometimes white, and sometimes red; the artificial was more useful to the chemist. He does not tell us how it was prepared, but he describes the method of subliming it, which can leave no doubt that it was real sal-ammoniac. In the *Opera Mineralia* of Isaac Hollandus the father, addressed to his son, there is likewise a description of the mode of subliming sal-ammoniac. There can be no doubt then, that true sal-ammoniac was known in the thirteenth century. Basil Valentine, in his *Currus Triumphalis Antimonii*, describes some of the peculiar properties of sal-ammoniac in a still less equivocal manner, if possible. But after the two older writers already quoted, his evidence is unnecessary.

Sal-ammoniac occurs native in Bucharia, and probably in other parts of the world. It is found also in small quantities near volcanoes, being formed during the extraordinary convulsions of these mountains. This fact seems in corroboration of an opinion advanced by some mineralogists, that the principal fuel of volcanoes is pit-coal, and that they are always

moistened with sea-water; for sal-ammoniac is sublimed in small quantities during the burning of London bricks, the sand of which is brought from the sea-shore, while the fuel is pit-coal.

In the Latin, English, and French chemical books, published in the seventeenth, and the beginning of the eighteenth century, the name of this salt is usually written *sal-armoniac*. This we conceive to be an old German word; for Agricula has given us an alphabetical catalogue of all the Latin technical terms which he uses in his works, with a German translation of each. Now, the German translation which he gives of *sal-ammoniacus* is *sal-armoniac*. The present German name for this salt is *salmiak*.

Egypt is the country where sal-ammoniac was first manufactured, and from which Europe for many years was supplied with it. This commerce was first carried on by the Venetians, and afterwards by the Dutch. Nothing was known about the method employed by the Egyptians till the year 1719. In 1716, Geoffroy junior read a paper to the French Academy, showing that sal-ammoniac must be formed by sublimation. But his opinion was opposed so violently by Homberg and Lemery, that the paper was not printed. In 1719, M. Lemaire, the French Consul at Cairo, sent the Academy an account of the mode of manufacturing sal-ammoniac in Egypt. The salt it appeared was obtained by simple sublimation from soot. In the year 1760, Linnæus communicated to the Royal Society a correct detail of the whole process, which he had received from Dr Hasselquist, who had travelled in that country as a naturalist. This account is published in the 51st volume of the *Philosophical Transactions* (1760, p. 504.) Almost the only fuel used in Egypt is the dung of cattle. This is collected during the four first months of the year, when the cattle feed on spring grass, which in Egypt is a kind of clover. It is dried, and sold to the common people as fuel. The soot from this fuel is carefully collected and sold to the sal-ammoniac makers, who only work during the months of March and April; for at other periods of the year the dung of their cattle is not fit for their purpose. An oblong oven is built of bricks and moist dung, as long again as broad, and of such a size that the outside or flat part of the top of the arch may hold fifty glass vessels, ten in length, and five in breadth, each vessel having a cavity left for it in the brick work of the arch. These glass vessels are globular, with a neck an inch long, and two inches wide. In general, they are about eighteen inches in diameter. Each vessel is coated over with a fine clay found in the Nile, and afterwards with straw. They are filled two-thirds with soot, and put into their holes at the top of the oven. At first a gentle fire is raised, and the temperature is gradually increased to the highest degree, at which it is kept for three days. A smoke with a sourish smell, not unpleasant, issues first from the glasses, then the salt sublimes, and coats the upper part of the vessel.

It was long supposed, that camels' urine and camels' dung were essential for the success of the above process. But this is a mistake. The dung of black-cattle, horses, sheep, goats, &c. are all used promiscuously. The dung of these animals contains the sal-ammoniac ready formed. This depends upon the food which the animals live on, and accordingly it is only fit for the purpose at one season of the year. The soot contains the sal-ammoniac likewise ready formed, and merely mixed with a quantity of charcoal, oil, &c. from which it is freed by sublimation. Chaptal informs us, that he found sal-ammoniac in the soot obtained by burning the dung of cattle that had fed on the saline plants in the marshes near the Mediterranean. Thus the Egyptian method of obtaining sal-ammoniac is the simplest possible.

The first attempt to manufacture sal-ammoniac in Europe was made by a Mr Goodwin, a chemist of London, about the beginning of the eighteenth century. We do not know his process accurately; but he appears to have used the mother ley of common salt and putrid urine as ingredients. Dossie, in his *Institutes of Experimental Chemistry*, gives it as his opinion, that the salt obtained by this process was not sal-ammoniac, but sulphate of ammoniac, and even describes a process for subliming that salt. But he must have been mistaken; for sulphate of ammoniac, as appears from the experiments of Hatchett, is entirely decomposed when we attempt to sublime it. Goodwin's process, however, whatever it was, did not succeed, and was speedily abandoned. In the year 1740, a patent was taken out for making sal-ammoniac by a London manufacturer. The process was nearly the same as Goodwin's, and was equally unsuccessful. The first successful manufacture of sal-ammoniac in this country was established in Edinburgh by Dr Hutton and Mr Davy. We do not know in what year the manufactory was begun, but as the plan was concerted while these gentlemen were students at the university of Edinburgh, the establishment of the work cannot have been far from the year 1760. From the University of Edinburgh, Dr Hutton went to Paris. During his absence, Mr Davy began the manufactory, and, on his return, admitted him as a partner. This original manufactory existed in Edinburgh till within these few years. The low price of sal-ammoniac during the war with Russia, induced the proprietors to abandon it, as was the case with almost all the sal-ammoniac works in Britain.

Sal-ammoniac was first manufactured in France by Baumé, who established a work about the year 1760; but whether it was posterior or anterior to the work of Hutton and Davy, we do not know. Manufactories of it were afterwards established in Germany, Holland, and Flanders.

Various modes were followed in Europe to procure this salt. But the theory (if we can apply the term here) of most of the manufacturers was the same. They formed a sulphate of ammonia, which they mixed with common salt. A double decomposition took place. The sulphuric acid of the sulphate united with the soda of the common salt, and formed Glauber's salt, which was obtained in great abundance by crystallization, and sold as a medicine. The muriatic acid and ammonia, uniting together, formed sal-ammoniac, which was sublimed. When the British Government imposed a heavy duty on Glauber salts, the manufacture of sal-ammoniac in

Ammoniac, Sal.

this country received so severe a blow, that it is not likely ever to recover it. We shall give a short sketch of the processes followed in different manufactories, in order to afford a more distinct idea of the method of procuring this salt.

Before the French revolution, several manufactures of sal-ammoniac existed in Flanders, which deserve to be described; first, because they were in some measure an imitation of the original Egyptian method. Bricks, or rather balls, were formed of the following materials: twenty-five parts of pounded pit-coal, five parts of soot, two parts of clay, and as much of a saturated aqueous solution of common salt, as was sufficient to convert the whole into a paste; this paste was molded in an iron mould, and the balls suffered to dry. These were burnt in a brick furnace, along with a quantity of dry bones, the proportion of which does not appear to have been accurately determined. The furnace communicated by an aperture, two inches wide, into a vaulted brick chamber above. From the top of this chamber, there was a communication, likewise two inches wide, with a horizontal gallery, which terminated in a perpendicular chimney. The fire was kept up with these materials for five or six months, and then allowed to go out. By the combustion of the pit-coals, soot, and bones, a quantity of carbonate of ammonia is formed. The common salt is decomposed by the clay, and muriatic acid disengaged. This acid coming in contact with the carbonate of ammonia, decomposes it, and sal-ammoniac is formed. The sides and roof of the vaulted chamber are found coated with this impure sal-ammoniac, which is carefully removed. The bottom of the chamber, and the horizontal gallery above, contain likewise sal-ammoniac; but so much loaded with bitumen, that it requires to be burnt a second time before the sal-ammoniac can be extracted. The impure sal-ammoniac is put into egg-shaped clay vessels, twenty inches long, and sixteen in diameter. Each is filled to within three inches of the top. The lower part of these vessels is exposed to a graduated heat for forty-eight hours, while the upper part, being left in the air, is comparatively cool. The oily matter is first driven off; and then the sal-ammoniac is sublimed in a cake in the upper part of the vessel. The charcoal, and any other fixed matter present, remains at the bottom. Finally, the clay vessels are broken, and the cakes of sal-ammoniac taken out. There is a small hole in the upper part of the clay vessels, and care is taken to keep this hole open during the whole process, to prevent the vessels from bursting. Fifteen parts of the sooty matter, taken from the vaulted chambers, yield about five parts of sal-ammoniac. *Journal des Mines*, No. x. p. 3.

The original process of Baumé was to distil animal substances, in order to procure from them carbonate of ammonia. With this salt he decomposed the muriate of magnesia, which exists in considerable quantity in the mother ley of common salt, when that substance is procured from sea water; the liquid containing the sal-ammoniac was evaporated, and the sal-ammoniac sublimed.

This process was speedily abandoned, and another substituted in its place, by MM. Leblanc and Dizé. They brought into contact, in a leaden chamber, vapours of ammonia and of muriatic acid. The ammonia was procured by distilling animal substances, and the muriatic acid by decomposing common salt by means of sulphuric acid. But this method, though it yielded a very pure sal-ammoniac, was speedily abandoned on account of its expence.

The process of Hutton and Davy was to procure ammonia, which they did chiefly from soot. This they converted into sulphate of ammonia. The sulphate was mixed with common salt, and thus two salts were procured; Glauber's salt, which they obtained by crystallization, and sal-ammoniac, which was sublimed.

Almost all the manufactures of sal-ammoniac, whether in Britain, France, or Germany, were similar in principle to that of Hutton and Davy. The only difference consisted in the means employed to procure the sulphate of ammonia. We shall describe a manufacture, formerly existing in London, in which the methods employed were both scientific and economical.

The material from which the ammonia was extracted was bones. These were collected in the streets, and from dunghills, chiefly by old women. The bones were bruised and boiled, in order to extract the fat which they contained, which was sold to the soap-makers. They were then put into iron cylinders eight feet long, and three feet in diameter, placed horizontally over a fire-place, so that they could be made red hot. At one end of the cylinder was a mouth, about fourteen inches in diameter, by which the bones were introduced. This mouth was accurately shut by a cover, and made air-tight by means of lute. From the other end of the cylinder proceeded a cast-iron pipe, from six to eight inches in diameter, and twenty feet long, terminating in one or more oblong leaden receivers, which were kept cool by water placed in a leaden vessel, the bottom of which formed their cover, the juncture being secured by lute. Of these receivers there were commonly two to each still, or three to two stills. Every receiver was about twelve feet long, one foot deep, and fourteen inches wide; and the refrigeratory that covered it held about four inches in depth of water. At the end most remote from the still was a pipe, fitted with a wooden plug, for the purpose of drawing off the condensed liquor; and above this was a hole through which the gas and uncondensible vapour passed off into the open air.

A single charge of each still yielded about 36 pounds of impure alkaline liquor, and about 30 pounds of black fetid oil floating on its surface. This latter being skimmed off, the ammonia was saturated with sulphuric acid, either by means of the mother liquor from the green vitriol makers, or still more economically by means of calcined and pulverized gypsum. In this last case the materials were mixed, and left in contact for some hours. A double decomposition took place; the sulphuric acid of the gypsum uniting with the ammonia, while the carbonic acid of the carbonate combined with the lime of the gypsum. The solution of sulphate of ammonia thus produced was mixed with common salt, by which Glauber's salt and sal-ammoniac were formed, and separated from each other.

For this purpose the liquid, clarified by subsidence and decantation, was transferred into oblong leaden boilers, about nine feet long, three wide, and nine inches deep. Two-thirds of the length of these boilers were set upon iron plates heated by a fire beneath; the remaining part was supported by flat tiles, and defended from the heat by a solid brick work. As the water evaporates, the Glauber's salt begins to crystallize. It is swept from time to time to the cool extremity of the boiler, whence it is shovelled into baskets placed over the end of the boiler, that the liquid which drains off may not be lost. The evaporation is continued till feathered crystals of sal-ammoniac begin to appear on the surface. The liquid is then run into coolers, and deposits little else than sal-ammoniac till the temperature sinks to 70°. The crystals must now be removed, that they may not be mixed with the Glauber's salt, which begins at that temperature to be deposited. The sal-ammoniac thus obtained is first drained in baskets, and then exposed to heat in a kind of oven, till the water of crystallization is driven off. It becomes spongy, friable, of an ash-colour, mixed with small white filaments.

This salt is introduced, while still hot, into globular grey earthen jars, fitted with a cover (with a hole of about half an inch diameter in its centre), luted on with a mixture of clay and horse-dung. These are set in earthen pots over a strong fire, in a furnace of either a circular or oval form, and capable of containing from six to eighteen, surrounded with sand up to the edge of the pot, and also having about 2½ inches of sand on the cover, confined by an iron ring about three inches deep, and two inches less in diameter than the cover, in order that the luting, should it give way, may be repaired without suffering the covers to be cooled by the removal of the sand; for, during the sublimation, their temperature should be about 320°. These earthen vessels may be filled with the dried salt, to within two inches of the top. It may be gently pressed in, but not rammed close. The fire, which has been lighted some time before, is now to be raised gradually till the iron pots are of a pretty strong red heat all round. They are so placed in the furnace, that the upper part is first heated; the bottoms resting on solid brick work. At first, a quantity of aqueous vapour, carrying with it a portion of the salt, escapes through the hole in the cover. The hole must be left open as long as any moisture exhales. This is known by bringing a cold smooth iron plate near the hole, in order to condense the sublimate. When the water is gone, the salt attaches itself to this plate, in the form of a dry semi-transparent crust. The hole is now to be stopped up with lute, and more sand put upon the cover. The heat is to be kept up till it is judged that most of the sal-ammoniac, but not the whole, has sublimed. The time requisite for this depending on the furnace, can only be learned by experience. If the heat be continued too long, the cake of sal-ammoniac acquires a yellow colour, and a scorched, opaque, crackled appearance, which, injuring its saleability, ought to be avoided. When the lute gives way, and requires repairing during the process, the appearance of the cake of sal-ammoniac is injured. On this account, glass vessels would be preferable to those of clay. But, in this country, the expence of glass is so great, on account of the high duty laid upon it, that manufacturers are scarcely able to use it in those cases where the vessels must be broken at the end of every process, as is the case in the sublimation of sal-ammoniac. Aikin's *Dictionary of Chemistry*, art. Sal-Ammoniac.



One process more deserves to be mentioned, on account of its ingenuity and simplicity. It is the invention of Mr Astley, who has secured the exclusive privilege by a patent, and has a manufactory at Borrowstowness on the Firth of Forth, and another at Portobello, near Edinburgh. He mixes together animal matters (chiefly woollen rags), with what in Scotland is called *spirit of salt*. It is the mother ley that remains after all the crystals of common salt that can be got have been separated from sea water. It consists chiefly of muriate of magnesia. This mixture is burnt in furnaces, and the produce received in small chambers placed over the furnaces. This produce contains abundance of sal-ammoniac, which is obtained pure by sublimation. We conceive the theory of this process to be, that carbonate of ammonia is formed by the combustion of the animal matter. This carbonate immediately decomposes the muriate of magnesia, and sal-ammoniac sublimes. In principle, therefore, it does not differ from Baumé's original process, though, in point of economy, it is probably greatly superior to it. We have little doubt that Baumé's method yields a greater return from the same quantity of materials; but this is probably much more than counterbalanced by the much greater expence attending his process. Nothing can demonstrate this more clearly than the circumstance that his method was abandoned in France as too expensive, though labour be much cheaper in that country than in this, while Mr Astley manufactures his sal-ammoniac with profit in the neighbourhood of Edinburgh. (J.)

AMPHIBIA. See Reptilia in *Index* to the article Vertebrosa.

ANA, a Latin plural termination, appropriated to various Collections of the observations and criticisms of eminent characters delivered in conversation, and recorded by their friends, or discovered among their papers after their decease. Though the term Ana is but of modern origin, the species of composition to which it has been applied, is not of such recent date as some persons have imagined. It appears from D'Herbelot's *Bibliotheque Orientale*, that, since the earliest periods, the Eastern nations have been in the habit of preserving the maxims of their sages. From them this practice passed to the Greeks and Romans. Plato and Xenophon treasured up and recorded the sayings of their master Socrates. From their example, Arrian, in the concluding books of his *Enchiridion*, which have not descended to posterity, collected the casual observations which had dropped from Epictetus. The numerous apophthegms scattered in Plutarch, Diogenes Laertius, and other writers, evince that it had been customary in Greece to preserve the ideas deliver-

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ed by illustrious characters. It appears that Julius Cæsar compiled a book of apophthegms, in which he related the *bon-mots* of Cicero; and Quintilian informs us, that a freedman of that celebrated wit and orator composed three books of a work entitled *De Jocis Ciceronis.* We are told by Suetonius that Caius Melissus, originally the slave, but afterwards the freedman and Librarian of Mæcenas, collected the sayings of his master; and Aulus Gellius has filled his *Noctes Atticæ* with anecdotes which he heard from those distinguished characters whose society he frequented in Rome. Were the books compiled by the freedmen of Cicero and Mæcenas now extant, they might be entitled Ana; and it is certainly to be regretted, that we possess no authentic record of the conversational remarks or hints which dropped from the sages, orators, or statesmen of Greece and Rome. How interesting would be a *Colloquia Mensalia* of Atticus or Cæsar!

But, though vestiges of this species of composition may be traced in the classical ages, it is only in modern times that it has attained to full popularity and perfection. Literary anecdotes, critical reflections, and historical incidents, came to be mingled with the detail of *bon-mots* and ludicrous tales; so that instruction and entertainment were agreeably blended. The term Ana seems to have been applied to such collections as far back as the beginning of the fifteenth century. Thus, Francesco Barbaro, in a letter to Poggio, says, that the information and anecdotes which Poggio and Barthelemi Montepolitiano had picked up during a literary excursion through Germany, will be called *Ana:* "Quemadmodum Mala ab Appio e Claudia gente *Appiana*, et pira a Mallio *Malliana* cognominata sunt, sic hæc literarum quæ vestra ope et opera Germania in Italia deferetur, aliquando et *Poggiana* et *Montepolitiana* vocabuntur."

Poggio Bracciolini, to whom this letter is addressed, and to whom the world is indebted for the preservation of so many classical remains, is the first eminent person of modern times whose jests and opinions have been transmitted to posterity. Poggio was secretary to five successive Popes. During the pontificate of Martin V. who was chosen in 1417, Poggio and other members of the Roman Chancery were in the habit of assembling in a common hall adjoining the Vatican, in order to converse freely on all subjects. Being more studious of wit than of truth, they termed this apartment *Buggiale;* a word signifying a place of recreation where tales are related, and which Poggio himself interprets *Mendaciorum Officina.* At these meetings Poggio and his friends discussed the news and scandal of the day, and communicated to each other entertaining anecdotes; they attacked what they did not approve, and they approved of little: they also indulged in the utmost latitude of satiric remark; dealing out their sarcasms with such impartiality, that they did not spare even the Pope and Cardinals. The pointed jests and humorous stories which occurred in these unrestrained conversations were collected by Poggio, and formed the chief materials of his *Facetiæ*, first printed, according to De Bure, in 1470. This celebrated collection, which forms a principal part of the *Poggiana*, is chiefly valuable as recording interesting anecdotes of eminent men of the fourteenth and fifteenth centuries. It also contains a number of quibbles or *jeux-de-mots*, and a still greater number of idle and licentious stories. Many of these, however, are not original, some of them being taken from ancient authors, and a still greater number from the *Fabliaux* of the *Trouveurs.* Thus the *Fabliau La Culotte des Cordeliers*, is the *Braccæ Divi Francisci* of Poggio. *Le Meunier d'Aleus*, is Poggio's *Quinque Ova. Du Vilain et de sa Femme*, is his *Mulier Demersa*, and *du Pré Tondu*, is the *Pertinacia Muliebris* of the *Facetiæ.* On the other hand, Poggio has suggested much to succeeding writers. Hans Carvel's *Ring*, is his *Visio Francisci Filelfi;* and Fontaine's fables,—*Le Charlatan, Le Coq et le Renard*, and that of the *Wolf and Fox* pleading before the Ape, are from stories originally related by Poggio. The *Facetiæ* forms, upon the whole, the most amusing and interesting part of the *Poggiana* printed at Amsterdam in 1720; but this collection also comprehends some farther anecdotes of his life, and a few scattered maxims extracted from his graver compositions.

Poggiana.

Though Poggio was the first person whose remarks and *bon-mots* were collected under the name of Ana, the *Scaligerana*, which contains the opinions of Joseph Scaliger, was the first work *published* under that appellation; and accordingly may be regarded as having led the way to that class of publications.

Scaligerana.

There are two collections called Scaligerana—a *prima* and *secunda* Scaligerana. The first was compiled by a Physician, named Francis Vertunien, Sieur de Lavau, who attended the family of the Messieurs Chateigner, in whose house Joseph Scaliger resided. He, in consequence, had frequent opportunities of meeting that celebrated critic, and was in the custom of committing to paper the learned or ingenious observations which dropped from him in the course of conversation; to which he occasionally added remarks of his own. This collection, which was chiefly in Latin, remained in manuscript many years after the death of the compiler. It was at length purchased by M. de Sigogne, who published it in 1669, under the title of *Prima Scaligerana, nusquam antehac edita;* bestowing upon it the title *prima*, in order to preserve its claim of priority over another Scaligerana, which had been published three years before, but had been more recently compiled. This second work, known by the name of *Secunda Scaligerana*, was collected by two brothers of the name of Vassan, who went to complete their studies at the University of Leyden, of which Scaliger was at that time one of the Professors. Being particularly recommended to Scaliger, they were received in his house, and daily enjoyed his conversation; in the course of which, he gave them much information concerning various topics of history and criticism. The Vassans immediately wrote down what they had heard, and soon made up a large manuscript volume, in which, however, there was neither connection nor arrangement of any description. In this state, the manuscript was delivered by one of the Vassans, on his retirement to a monastery, to M. de Puy; and after passing through various hands, it came into the possession of M. Daillé, who, for his own use, arranged the articles it contained in alphabetical order. Isaac

Ana.

Vossius having come to Paris on a visit to M. Daillé, obtained the loan of the manuscript, which he transcribed, and afterwards published at the Hague, under the title of *Scaligerana, sive excerpta ex ore Josephi Scaligeri.* This edition was full of inaccuracies and blunders; but a more correct impression was afterwards published by M. Daillé, with a preface complaining of the use Vossius had made of the manuscript, which he declares was never intended for publication, and was not of a nature to be given to the world. Indeed, most literary men in that age conceived, that the *Scaligerana*, particularly the *second*, detracted considerably from the reputation of the great scholar whose sentiments they recorded. They are full of mistakes and contradictions; and Bayle has remarked, that the Vassans attribute to him observations which it is almost impossible he could have uttered. Joseph Scaliger, with more extensive erudition, but less genius than his father, Julius Cæsar Scaliger, had inherited his ridiculous vanity and dogmatical spirit. He wished it to be thought that he knew everything, and that his opinions were infallible. Conversing with two young students of an university, of which he formed the principal ornament, he would probably be but little cautious in the opinions he expressed, as his literary errors could not be detected or exposed. Unfortunately, the blind admiration of his pupils led them to regard even his most absurd opinions as the responses of an oracle, and his most unmerited censures as just condemnations. The *Scaligerana*, accordingly, contain many falsehoods, with much unworthy personal abuse, of the most distinguished characters of the age. Thus, he calls Cardinal Bellarmin a mere atheist (*plane atheus*), and compares the Duke of Sully to Sejanus. Indeed, M. Daillé, in his preface to the *Secunda Scaligerana*, confesses that it contains "multa futilia, scurrilia, obscæna; quædam manifeste falsa. Ubique de se suisque magnifice, ne dicam, thrasonice, loquitur—laudum parcus, convitiorum largus, in omnes contumeliosissime invehitur—denique neminem sibi de manibus elabi patitur, cujus non errata, vitia, nævos etiam levissimos, acerrime insectetur, et plusquam cynica licentia arrodat."

In imitation of the *Scaligerana*, a prodigious number of similar works appeared in France, towards the end of the seventeenth, and beginning of the eighteenth century. At first, these collections were confined to what had fallen from eminent men in conversation; but they were afterwards made to embrace fragments found among their papers, and even passages extracted from their works, and epistolary correspondence. Of those which merely record the conversations of eminent men, the best known, the fullest, and most valuable, is the *Menagiana*. Menage was a person of good sense, of various and extensive information, and of the most communicative disposition. He lived during the greater part of his life in the best society. An assembly of literary characters met, during a long period of time, at his house every Wednesday; and, during his latter years, he daily received persons of that description. Much of his time was thus spent in conversation; and those of his friends who habitually enjoyed it were at pains to record his opinions, which were generally founded on a correct taste and judgment; and were always delivered in a manner the most interesting and lively. A collection of his oral opinions was published in 1693, soon after his death; and this collection, which was entitled *Menagiana*, was afterwards corrected and enlarged by M. La Monnoye, in an edition published by him in 1715. Among the most curious articles in the *Menagiana* may be numbered the dissertation on *Le Moyen de Parvenir*, a work attributed to Beroalde de Verreville; that on *Le Songe de Poliphile*; as also a letter of La Monnoye on the existence of a book supposed to have been entitled *De Tribus Impostoribus*, concerning which there has been much discussion and controversy.

Perroniana.

The *Perroniana*, which exhibits the opinions of Cardinal Perron, was composed from his familiar conversation, by M. de Puy, and published by Vossius, by the same contrivance which put him in possession of the *Scaligerana*. Some parts of this collection are useful in illustrating the literary and ecclesiastical history of the age in which Perron lived; but it also contains many puerile, imprudent, and absurd remarks, which it is generally supposed he never uttered, and many of which were proved by M. Chevreau (*Chevraeana*) to have been the interpolations of his friends. Some of his assertions,—as that Luther denied the immortality of the soul, and that every English peasant drinks from a silver goblet,—are evidently false. Nor can much reliance be placed on the judgment or taste of an author, who has elsewhere declared, that a page of Quintus Curtius is worth thirty of Tacitus, and that, next to Quintus Curtius, Florus is the greatest Roman Historian.

Thuana.

The *Thuana*, or observations of the President De Thou, have usually been published along with the *Perroniana*. This collection is not extensive, and by no means of such value as might have been expected from a man so able and distinguished.

Valesiana.

The *Valesiana* is a collection of the literary opinions of the historiographer Adrian Valois, published by his son. M. Valois was a great student of history, and the Valesiana, accordingly, comprehends many valuable historical observations, particularly on the works of Du Cange.

Fureteriana.

The *Fureteriana* contains the *bon-mots* of M. Furetiere, of the French Academy, the stories which he was in the habit of telling, and a number of anecdotes and remarks found among his papers after his decease. This production, however, consists chiefly of short stories, and comprehends but few thoughts, opinions, or criticisms on books. Furetiere, it is well known, had a violent quarrel with the French Academy, of which he was a member, concerning his *Dictionnaire Universel de la Langue Françoise*. Having published a preliminary discourse, the farther printing was interdicted by the French Academy, which accused him of purloining materials they had amassed for a similar work. This controversy subsisted during the rest of the life of Furetiere, who spent his concluding years in writing and publishing libels on his associates. The *Fureteriana*, accordingly, is replete with allusions to a subject with which his thoughts were so completely engrossed. In particular, we find there the plan

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and outline of an allegorical and burlesque poem, entitled *Les Couches de l'Académie;* in which he has satirized different members of the academy, especially M. Charpentier, one of his bitterest foes, whom he has designated by the name of *Marmentier*.

Chevraeana.

The *Chevraeana*, so called from M. Chevreau, exhibits more research than most works of a similar description; and is probably more accurate, as it was published during the life of the author, and revised by himself. Among other interesting articles, it contains a learned and ingenious commentary on the works of Malherbe, to whom the French language and poetry were highly indebted for the perfection to which they attained.

Parrhasiana.

*Parrhasiana* is the work of Jean Le Clerc, a Professor of Amsterdam, who bestowed this appellation on his miscellaneous productions, with the view of discussing various topics of philosophy and politics, with more freedom than he could have employed under his own name. This work is not of the light and unconnected description of most of the Ana which have been above enumerated; as it contains much learned philological disquisition, and a long dissertation on poetry and eloquence. In the first volume, there is a list of his published works, and a bitter reply to all those who had censured them.

Huetiana.

The *Huetiana*, which has always held a distinguished place among the Ana, contains the detached thoughts and criticisms of Huet, Bishop of Avranches, which he himself committed to writing during his life. This author was well fitted to produce a valuable work in this department of literature. He enjoyed the friendship of a number of distinguished characters, and his reading was various and extensive. This collection, however, was not begun by him till he was far advanced in life. Huet was born in 1630, and, in 1712, he was attacked by a malady which impaired his memory, and rendered him incapable of the sustained attention necessary for the completion of a long or laborious work. In this situation, he employed himself during the concluding years of his life in throwing his detached observations on paper. These were published by the Abbé d'Olivet the year after his death, under the name of *Huetiana;* a work which is not, like some other Ana, a succession of *bon-mots* or anecdotes; but forms a series of thoughts and criticisms on various topics of morals, philosophy, and literature; and also comprehends pretty long dissertations on the origin of rhyme, the comparative merit of the ancients and moderns, with similar topics. One of the most instructive discussions to a scholar, in this collection, is that on the Latinization of names and surnames; in which he points out and criticises the different modes of this process. His critical judgments on Montaigne, Rochefoucauld, and Tacitus, seem also well founded; and if some of his opinions in matters of taste betray singular or defective feelings, there are others which appear equally just and refined. But were there no other literary memorials of the Bishop of Avranches, he certainly would not derive high reputation from the *Huetiana*. D'Alembert has treated this collection with contempt; and has selected some articles to show the Bishop's incompetent judgment and frivolous taste. It may be suspected, indeed, from the circumstances in which the articles contained in the *Huetiana* were composed, that they do not always display that correct judgment which distinguishes many of the other works of this learned writer.

Casauboniana.

The *Casauboniana* presents us with the miscellaneous observations, chiefly philological, of the celebrated Isaac Casaubon. During the course of a long life, that eminent commentator was in the daily practice of committing to paper any thing remarkable which he heard in conversation with his friends, especially if it bore on the studies in which he was engaged. He also made diurnal annotations on the works he was employed in reading, with which he connected his judgments concerning the author and his writings. This compilation, which was styled *Ephemerides*, together with his *Adversaria*, and materials amassed for a refutation of the *Ecclesiastical Annals of Baronius*, came, at his death, into the possession of his son, Meric Casaubon, who bequeathed the whole to the Bodleian Library at Oxford. These were shown to Christopher Wolfius, during a visit which he paid to that university, and having been transcribed by him, were published under the title of *Casauboniana*. This collection consists of opinions concerning various eminent writers; illustrations of passages in scripture; and philological observations and animadversions on the thirty-four first years of the *Annals of Baronius*. The materials and information which it contains are probably more accurate than is usually the case in works of the same description; as they were not communicated in casual conversation, and reported by others, but were daily committed to writing by Casaubon himself, while the works from which they were derived remained fresh in his recollection.

Besides the above, a great many works, under the title of Ana, appeared in France about the same period. Thus, the opinions and conversation of Charpentier, Colomesius, and St Evremond, were recorded in the *Carpenteriana*, *Colomesiana*, and *St Evremoniana;* and those of Segrais in the *Segraisiana;*—a collection formed by a person stationed behind the tapestry in a house where Segrais was accustomed to visit, and of which Voltaire has declared, "que de tous les Ana c'est celui qui merite le plus d'être mis au rang des mensonges imprimés, et surtout des mensonges insipides." The Ana, indeed, from the popularity which they now enjoyed, were compiled in such numbers, and with so little care, that they became almost proverbial for inaccuracy. About the middle of the eighteenth century, they were sometimes made the vehicles of political squibs,—as in the *Maupeouana*, and of heretical opinions,—as in the *Longueruana*. Thus, the evil naturally began to cure itself, and by a re-action, which is very general in regard to all productions of literature, the French Ana sunk in public esteem, as much below their intrinsic value, as they had formerly been exalted above it.

Carpenteriana. Colomesiana. Evremoniana. Segraisiana

Maupeouana. Longueruana.

Although these collections have been chiefly formed from the oral opinions of eminent men on the Continent, particularly in France, England has also produced one or two examples of this species of composition, which are not altogether undeserving

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of attention. Of these, perhaps, the most curious is the *Walpoliana*, which is a transcript of the literary conversation of Horace Walpole. That multifarious author was distinguished for his resources of anecdote, wit, and judicious remark, as well as for his epistolary qualifications. From his father, Sir Robert Walpole, he had learned many anecdotes concerning the political characters who figured during the period of his administration. He was himself personally acquainted with all the eminent literary characters of his own day in England; and his repeated visits to Paris, and constant correspondence with friends in that Capital, supplied him with the most interesting information with regard to France. A great part of his life was devoted to conversation. While residing at Strawberry-hill, he generally rose from table about five o'clock, and taking his place on his drawing-room sofa, to which his gout in a great measure confined him, he passed the time till two o'clock in the morning, in miscellaneous chit-chat, full of singular anecdotes, strokes of wit, and acute observations. As he possessed, and was daily communicating such stores of instruction and amusement, it was suggested to him that he ought to form a collection of these anecdotes and observations. This he declined, but he furnished the editor of the *Walpoliana* with many anecdotes in his own hand-writing. After his death, several specimens of this miscellany were published in the *Monthly Magazine;* and being afterwards enlarged by anecdotes, retained in the memory of the editor, or communicated by others, were published in two volumes, under the title of *Walpoliana*. Most other works, which, in this country, have been published under the name of *Ana*,—as *Baconiana*, *Atterburyana*,—are rather extracts from the writings and correspondence of eminent men, than memorials of their conversation.

There are some works which, though they do not bear the title, belong more strictly to the class of Ana than many of those collections which are known under that appellation. Such are the *Mélange d'Histoire et de Litterature*, published under the name of *Vigneul Marville;* and the *Locorum Communium collectanea, ex Lectionibus Philippi Melanchthonis;*—a work which was published as far back as the sixteenth century, and has obtained considerable reputation on account of its theological learning, and the information it communicates concerning the early state of the reformed church. But of those productions which belong to the class, though they do not bear the name of Ana, the most celebrated are the *Colloquia Mensalia* of Luther, and Selden's *Table-Talk*,—both of which merit particular notice. The first, which comprehends the conversation of Luther with his friends, and coadjutors in the great work of the Reformation, was first published in 1566. Captain Henry Bell, who translated it into English, in the time of the Commonwealth, informs us, that, at the instigation of the Pope, the Emperor of Germany had promulgated an edict commanding the works of Luther to be destroyed. It was for some time supposed that all the copies of the *Colloquia Mensalia* had been burned in consequence of this order; but at length, in 1626, a German called Van Sparr, having occasion to build on the old foundation of a house in which his grandfather dwelt, when the imperial edict was issued, he found lying in a deep hole, and wrapped up in a linen cloth, a printed copy of the *Colloquia Mensalia*. Captain Bell, having formerly become acquainted with Van Sparr during a long residence in Germany, his friend transmitted the work to him in England, where he executed a translation of it; an undertaking to which he pretends that he was urged by the vision of an old man with a long white beard, arrayed in white, who spoke these words: "Sirrah, will you not take time to translate that book?" The extraordinary book translated by Bell, at the instance of this vision, is said to have been originally collected by Dr Anthony Lauterbach, "out of the holy mouth of Luther;" and was afterwards digested into common-places by Dr John Aurifaber. It chiefly contains observations and discussions on idolatry, auricular confession, mass, excommunication, clerical jurisdiction, general councils, and all the points agitated by the reformed church in those early periods. With such topics, there is intermixed many diatribes against Antichrist and the Cardinals, and much sarcasm on popish miracles and relics. Occasionally, however, it must be confessed, that our great reformer expresses a belief in superstitions fully as wild and monstrous as those which he derides, and which he was called to overthrow. Thus, he asserted that he was repeatedly kept from sleep, by the Devil cracking nuts in his chamber; and he affirmed that there was a child at Dessaw, which had been substituted by the Arch-Fiend instead of one he had stolen away, and which child Luther earnestly advised the Prince of Anhalt to throw into the river Moldaw.

Luther's Colloquia Mensalia.

Selden's Table-Talk.

If the collection of Selden's apophthegms and sayings, entitled *Table-Talk*, be regarded of good authority, we shall find in it a more genuine and undisguised expression of the sentiments of that eminent man, than in his more studied productions. This work was published, after the death of Selden, by Richard Milward, his Amanuensis; who, in his dedication to Selden's executors, affirms, that, for twenty years, he enjoyed the opportunity of daily hearing his discourse, during which long period he made it his practice, from time to time, faithfully to commit to writing "the excellent things that usually fell from him." Dr Wilkins, in his introductory discourse to the works of Selden, has attempted to throw discredit on the authenticity of this compilation; asserting, that it contains many things derogatory from Selden's erudition, and foreign from his manners and principles. It is not improbable, indeed, that the memory of the Amanuensis may have occasionally failed him, and that he may have recorded sayings which inadvertently escaped his master in the heat of conversation, and such as he probably would not have deliberately maintained. But, on the whole, the work has completely an air of genuineness; and although the familiarity of his illustrations and parallels may appear to clash with the idea formed of so great a scholar, they are characteristic of a man who had been conversant with scenes of common life, no less than the speculations

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of the closet. That such was the usual manner of Selden's conversation, the Editor of the *Table-Talk* recalls to the recollection of those friends of his patron, to whom the work is dedicated; and this appeal forms a presumption of his veracity. The *Table-Talk* contains many curious facts and opinions concerning the political and ecclesiastical history of the interesting period during which Selden lived, and in the important events of which he bore a considerable share. To judge from this work, Selden had great contempt for the theologians of his day; and seems to have been of opinion that the State should invariably keep a rein on the Church. He was partial to the Episcopal form of worship; but was evidently not very strict in doctrinal points, as appears from what he is reported to have said on the subject of *heresy*. In his political opinions, he seems to have entertained a high respect for the sacredness of the social contract; and he justified the resistance to the Stewarts, on the ground that they had infringed and violated this compact between prince and people. Besides religious and political opinions, the *Table-Talk* contains much of a lighter description; in consequence of which, Selden has been accused of showing more laxness, in point of moral principle, than might have been expected from so grave and respectable a character. Many of those sentiments, however, which have been considered objectionable, may have been merely advanced as plausible deductions from principles assumed for the sake of argument. But whatever difference of opinion may exist, with regard to the matter of the *Table-Talk*, the manner in which the sentiments are there expressed must be universally admitted to be perspicuous and agreeable. The style of Selden, in most of the works published under his own care, is harsh and obscure; but Clarendon, who differed from him so widely in political opinions, acknowledges that he was "a clear discourser; and that he possessed the faculty of making difficult things easy, and presenting them clearly to the understanding." Accordingly, this talent for elucidation shines chiefly in his *Table-Talk;* which is filled with the stores of his extensive reading, delivered without any pretensions to that order and method, the want of which has been attributed to his other productions.

It thus appears, that although the compilations designated by the name of Ana belong more particularly to France, they have not been wholly unknown in this country. In their *Motti e Burle*, and sometimes in their Novels, the Italians also have recorded the witticisms of their distinguished poets and artists. The novels of Sacchetti are full of repartees attributed to Dante, and the Painters Giotto and Buffalmacco. Almost every Italian biographical work, of the sixteenth and seventeenth centuries, like Boswell's *Life of Johnson*, records at great length the conversational remarks of the individual whose life is detailed. Thus, Manso has dedicated one of the books of his life of Torquato Tasso to an account of the wise and witty sayings of that illustrious poet, who, towards the close of his days, had become the intimate friend of his biographer. The conversation of the poet, however, was neither gay nor brilliant: One of the characters in Goldoni's drama of Torquato Tasso thus contrasts his writings and conversation:

> Ammiro il suo talento, gradisco i carmi suoi;
> Ma piacer non trovo a conversar con lui.

It also unfortunately happens, that the greater part of the sayings recorded by Manso may be found in the Apophthegms of Erasmus, which were published before the birth of Tasso. Indeed, Manso seems to have been aware of the want of originality in the *bon-mots* of his friend; for, after mentioning one, he says, "questo motto fu da alcuni ad *Epiteto* attribuito." It was usual, indeed, among the biographers of those times, to pillage Xenophon or Plutarch, for good things to put into the mouths of their heroes; a practice from which Machiavel could not abstain in his short account of the illiterate soldier Castruccio Castracani. In these ages of pedantry, however, it is not improbable, that many sayings of the old philosophers might have been repeated as their own by the learned men of the times; and that the Italian *literati* might occasionally attempt to make their hearers merry with the jests of Socrates or Diogenes. The genius and character of the people rendered any collection of this nature less agreeable than the Ana of the neighbouring nation. In Italy, gravity was numbered among the virtues, and, in the eulogy of any illustrious man, is always mentioned as one of his most commendable qualities. There seems, in that country, to have been no medium between the most fantastic buffoonery, and a certain tragic solemnity. The Italians wanted that "mobility of imagination," that facility, rapidity, abandonment and gaiety, which seems almost peculiar to the French, and forms the chief charm of social intercourse, as well as of those works in which it is represented; though, no doubt, when reduced into writing, much of its grace and spirit must evaporate and disappear.

The existence of similar causes, and perhaps in a stronger degree, prevented the popularity of Ana among the Spaniards; though they too have related the jests and opinions of the Duke d'Ossuna, and of some others. Indeed, whatever may be the genius or disposition of a people, traces of this mode of composition may in some shape or other be discovered among them.

When presented in their most perfect form, which is that of the French Ana, these Collections are certainly entertaining from their variety, and curious, as presenting a lively image of the distinguished characters whose sentiments they record. If men reason more correctly on paper, they usually display their feelings and convictions with more truth in unpremeditated conversation. Few are so cautious or hypocritical, that they do not sometimes drop the mask in the society of their friends, and express what they think or feel, when they no longer entertain apprehensions that their sentiments will be communicated to the vulgar. In general, however, the Ana should rather be regarded as affording a notion of the spirit and turn of thinking of those whose conversation they detail, than as authorities for particular opinions. A spirit of contradiction,—a wish to display ingenuity,—to astonish by

paradoxes,—or even to support conversation, may often lead men to maintain opinions in colloquial intercourse which they perhaps never seriously held, or at least would be ready to disclaim on mature consideration. It also unfortunately happens, that in many of the Ana, those who collected the conversations which they presented to the world, interpolated their own opinions; which, of course, greatly diminishes their authority as characteristical records. It has also been objected to this species of composition, that every subject is treated superficially; but it should be recollected that the Ana do not profess to contain profound dissertations; and in fact no one consults them with the view of being deeply informed on any topic. A better founded objection is, that many subjects are treated, not merely superficially, but inaccurately. Such compositions are liable to a double risk of error; first, of the person who delivers opinions in the heat of discourse, or relates anecdotes from vague recollection; and, secondly, of the person who records them, who must be liable to mistake, what he has only heard in the course of conversation. From these causes, and from their wide and general circulation, many of the most current literary errors may be traced to the Ana. When read, however, with discrimination, they may prove highly useful, in illustrating various points of literary history; as they certainly contain a great deal which is not to be found in the formal compositions of the learned.



Wolfius has given a history of the ANA, in a preliminary discourse to his edition of the *Casauboniana*, published in 1710. In the *Répertoire de Bibliographies spéciales, curieuses et instructives*, by Peignot, there is a *Notice Bibliographique* of these Collections; but many of the books there enumerated consist of mere extracts from the writings of popular authors, and do not, therefore, belong to that class of literary works described in the preceding article. (M.)

ANALYSIS, ALGEBRAICAL. See MATHEMATICAL ANALYSIS.

ANALYSIS, CHEMICAL. See CHEMICAL ANALYSIS.

ANALYSIS, GEOMETRICAL. See MATHEMATICAL ANALYSIS.

ANALYSIS, METAPHYSICAL. See METAPHYSICAL ANALYSIS.

# ANATOMY.

THE provinces of Anatomy and Physiology may now, we believe, be looked upon as distinctly and permanently defined. Anatomy is understood to treat solely of the Structure of Living Bodies, and Physiology solely of their Functions.

We shall observe this arrangement strictly in the following article. It is one which, in our opinion, has already been productive of material advantages to the science of Vital Economy. The descriptive detail of the structure of Living Bodies is no longer distracted and obscured by superficial and unconnected views of their functions; nor their functions carelessly discussed, in the form of occasional and uninstructive commentaries on the descriptions of their structure. Each is made the subject of separate and particular investigation; and not only has Anatomy been thus rendered more accurate and precise, but a more regular and philosophical form has been given to Physiology, and its progressive improvement rendered more sure.

Living Bodies being arranged into two grand classes, Animals and Vegetables, the science of Anatomy, of course, comprehends two great divisions corresponding to these; viz. ANIMAL ANATOMY and VEGETABLE ANATOMY.

In the two following articles, we propose not only to trace the progress of improvement in each of those departments within these few years, but to correct several errors, and to supply many deficiencies, in the dissertations which relate to them in the body of the work.

## ANIMAL ANATOMY.

### I. HUMAN ANATOMY.

1. In our supplementary remarks on this first and most important department of Animal Anatomy, we shall endeavour, by the arrangement we intend to follow, to exhibit the outline of a plan better adapted, we conceive, for an elementary view of the structure of the Human Body, than that which has usually been observed in the schools of medicine, or in anatomical works.

But it will be necessary to premise a few observations on the acceptation of certain terms, which will occur very frequently in the descriptions that are to follow.

2. By the *period of impregnation* or *conception*, is uniformly meant the moment at which a child, or infant-being, begins to be formed within the womb of the mother.

While the child is yet retained within the womb, it is denominated a *fœtus* or *embryo*; the term *embryo*, however, being chiefly applied to it in its earlier stages.

The end of the ninth month after *conception*, which is the natural *period of birth*, is often denominated the *full time*.

The inhabitants of Great Britain, and perhaps of Europe in general, are usually *full-grown*, or *adult*, at the age of twenty-five or thirty years. This is the

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period of life, therefore, which we wish to be understood as denoted by the term *adult age*, or *maturity*.

Our descriptions are to be considered as applicable to the *adult male*, unless when the contrary is expressly specified.

To regulate the interpretation of the terms *above*, *below*, *before*, *behind*, &c. we shall uniformly suppose the body to be in the erect posture, with the arms hanging parallel to the trunk, and the palms of the hands, and the toes, turned directly forwards. This is a simple remedy, and the only effectual one, for the trifling ambiguity which might otherwise attend the use of these terms.

Any part of the body, or the surface of any part, which is capable of being divided, in one or more directions, into two portions or halves exactly alike, is said to be *symmetrical ;* and the line or plane separating them is called the *median line*, or *median plane*.

## PART I.

### OF THE EXTERNAL FORM, STATURE, AND WEIGHT OF THE BODY.

#### *External Form.*

Of the Fœtus.

3. There are very few anatomists who enjoy opportunities of ascertaining the gradual changes which take place in the external form of the fœtus during the earlier periods of its developement. The admirable series of engravings, therefore, in which Soemmerring has represented these changes, from the first to the fifth month after impregnation, will be consulted with great interest. (See *Icones Embryonum Humanorum.*)

An embryo of three or four weeks appears in these representations to the naked eye, somewhat like a mustard seed just beginning to grow ; the head being like the body of the seed, and the trunk and remaining parts like the radicle. With the magnifying-glass, however, a little dark circle can be distinctly seen in the regions of the eyes, and a small slit, corresponding to the orifice of the mouth. Four little prominences are observable on the trunk, in the situation of the four extremities ; and between the two lower, there is a curious prolongation like a tail, which has been called the *coccygeal protuberance*.

In an embryo of about seven weeks, the proportional size of the head is so much less, that the peculiar form of the human body is quite apparent. Two small pores are perceptible in the region of the nose ; and the superior extremities seem divided into arm and fore-arm.

In an embryo of about eight weeks, a small pore may be discovered, by the microscope, in the region of each auricle ; a shoulder, arm, fore-arm, and hand, with five small tubercles in the situation of the fingers, can be easily distinguished with the naked eye ; and in the lower extremities, parts can be seen corresponding to the thigh, leg, and foot ; but there is no appearance of toes.

In an embryo of about nine weeks, there is a projection in the region of the nose ; part of the auricles is formed ; the toes have appeared ; the pudenda begin to be distinguished ; and the coccygeal protuberance can no longer be seen.

After this, considerable changes take place in the external appearance of the fœtus, in proportion as the developement of the different parts advances ; but it would be impossible to convey an idea of these without the aid of engravings. Hair generally begins to appear on the eye-brows, and in the regions of the hind-head and temples, about the end of the fifth month.

4. Soemmerring has accompanied these representations with some remarks, which are worth attending to. The younger the fœtus, he finds, the larger is its head, compared to the other parts of the body ; the smaller its face, in proportion to the other parts of the head ; and the smaller its limbs, relatively to the trunk. During the first, second, and third months, he has remarked, that the upper extremities are larger than the lower ; but that, about the fourth, they are equal ; and that, towards the fifth, the lower have become larger than the upper.

Male and Female Fœtus compared.

5. He has also pointed out the following curious distinctions, in external form, between the male and the female fœtus. The head of the male differs from that of the female, in being larger in proportion to the whole body, less rounded, flatter in the crown, and more prominent behind. In the male, the breast is considerably more prominent than the umbilical region, while in the female it is the reverse ; and this is a distinction perceptible in the youngest fœtuses. The trunk of the body, between the upper parts of the loins, is arched in the male, but hollow in the female ; and this, too, is a distinction very early observable. The upper extremities in the male are a little longer, in proportion to the trunk, than in the female ; the arms are less cylindrical ; the fore-arms fuller ; the wrists broader ; and the ends of the fingers less pointed. The circumference of the body, at the haunches, is less in the male than in the female ; the thighs are more slender ; the feet longer ; the malleoli and heels more prominent ; and the great toe exceeds the others much more in length.

#### *Stature.*

Of the Male.

6. We believe the mean height of the male, at the period of maturity, to be about five feet eight inches English measure ; and the following are the comparative average dimensions of particular parts of the body :

| | *Inch.* |
|---|---|
| Total height of the body - - - - - - - | 68.00 |
| From the tip of one middle-finger to the tip of the other, the upper extremities being extended laterally to a right angle with the trunk - - - - - - - - - - - - | 68.00 |
| From the crown of the head to the top of the pubes - - - - - - - - - - - - | 34.00 |
| From the crown of the head to the lower margin of the chin - - - - - - - - | 9.75 |
| From the lower margin of the chin to the top of the breast - - - - - - - - - - | 3.85 |
| From the top of the breast to the pit of the stomach - - - - - - - - - - - | 6.08 |
| From the pit of the stomach to the navel - | 6.08 |
| From the navel to the top of the pubes - - | 6.08 |
| From the top of the prominence of the shoulder to the fold of the elbow - - - - | 12.06 |

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| | |
|---|---|
| From the fold of the elbow to the top of the hand | 10.02 |
| The hand, measured in the palm, from the lower fold of the wrist to the point of the middle-finger | 7.75 |
| From the top of the inside of the thigh to the inside of the joint of the knee | 14.06 |
| From the inside of the joint of the knee to the sole of the foot | 18.05 |
| The foot, measured on the sole, from the posterior margin of the heel to the point of the great toe | 9.75 |

Of the Female.

7. The average height of the female seems to be about five feet five inches; and the length of the different regions proportionally less than in the male.

Of the Fœtus.

8. The length of an embryo of three or four weeks represented by Soemmerring, is only about one-eighth of an inch; one of eight weeks is about an inch; and one at the end of the fifth month about ten inches. According to Mr Burns, (*Principles of Midwifery*, p. 121.) however, the fœtus, in the fifth month, is only about six or seven inches in length.

The same intelligent author states the length of the fœtus in the sixth month to be about eight or nine inches; in the seventh about twelve inches; and in the eighth about fifteen inches.

According to the observations of Roederer (*Comment. Reg. Soc. Scien. Gotting.* 1753), the length of the fœtus at the period of birth is, on an average, about $20\frac{1}{2}$ inches.

Of the Head of the Fœtus.

9. The only individual part of the fœtus, of which it is important to ascertain the average dimensions at the period of birth, is the head. Now, the longest diameter of the head, at this period, is that from the crown to the chin; and this seems in general to measure about five inches. The breadth of the head, at the same time, from one parietal protuberance to the other, is usually about $3\frac{1}{2}$ inches. In an exceedingly interesting paper in the *Philosophical Transactions* (*Phil. Trans.* 1786), Dr Clarke has stated, that he measured the heads of sixty male, and sixty female children, born at the full time; and that he found the circumference passing through the occipital protuberance, and the middle of the brow, to be, on an average, 13.8 inches; while the arch from ear to ear over the crown was 7.32 inches. One measured fifteen inches in circumference, and one $8\frac{1}{2}$ inches from ear to ear; but none were under twelve inches in the one direction, or $6\frac{1}{4}$ inches in the other.

Ratio of the Growth of Fœtus.

10. There are some general remarks on the progressive growth of the fœtus by Soemmerring, accompanying the engravings to which we have already referred, which present some singular results. According to him, the most rapid increase of the fœtus takes place during the first weeks after conception. He has observed, however, that the growth does not proceed in a uniform ratio; but that it is a little retarded during the second month; accelerated during the third; again somewhat retarded at the beginning of the fourth; from the middle of the fourth to the sixth again accelerated; and from this period till the end of the ninth month once more retarded.

Dimensions of the Male and Female Fœtus compared.

11. It seems to be well established, that there is a difference in the average dimensions of the male and female, even in the fœtal state. Roederer found the mean length of sixteen male children born at the full time to be $20\frac{10}{12}$ inches; and of eight females only $20\frac{4}{12}$; and Dr Clarke, in his measurement of the heads of sixty male, and sixty female children, born at the natural period, found that the circumference was, on an average, 14 inches in the males, and only $13\frac{5}{8}$ inches in the females, and the arch from ear to ear over the crown $7\frac{1}{4}$ inches in the males, and only $7\frac{1}{5}$ in the females. Out of one hundred and twenty children, there were only six in whom the circumference of the head exceeded $14\frac{1}{2}$ inches, and these six were males.

### *Weight.*

Of the Male.

12. We have examined a register of the weights of about fifty full grown males of the average stature, and find their mean weight to be about 140 lbs. English Troy. The average weight of an equal number of adult females, we suppose, would be found to be about 30 or 40 lbs. less; but we have had no opportunity of ascertaining this.

Of the Fœtus.

13. The average weight of the fœtus in the earlier months is uncertain. According to Mr Burns (*Principles of Midwifery*, p. 121), however, it generally weighs about 2 oz. in the twelfth week; about 1 lb. in the sixth month, and about 4 or 5 lbs. Troy in the eighth month.

At Birth.

14. Its mean weight at the natural period of birth has been better ascertained. It seems to be about 7 lbs. avoirdupois. The celebrated Dr Hunter (*Anatomical Description of the Gravid Uterus*, p. 68) states, that of several thousand new-born and perfect children, which were weighed at the British Hospital in London by Dr Macaulay, the smallest was about 4 lbs., and the largest about 11 lbs. 2 oz; but by far the greater number were from 5 to 8 lbs. avoirdupois. He adds, that he never knew an instance of a child born at the natural period that weighed 12 lbs. avoirdupois. Of sixty male and sixty female children, born at the full time, which were weighed by Dr Clarke, the lightest was 4 lbs., and the heaviest 10 lbs.; and the average weight was 7 lbs. 13 dr. avoirdupois. The average weight of twenty-six children, born at the natural period, which were weighed by Roederer, seems to have been about $6\frac{1}{2}$ lbs.; the heaviest being 8 lbs., and the lightest about $5\frac{1}{4}$ lbs.; but we are uncertain as to the scale of the weights which he employed.

15. Dr Clarke estimates the difference between the average weight of the male and female at birth at about 9 oz. avoirdupois; and the results of Roederer's observations do not appear to differ materially from this estimate.

Of Twins.

16. In cases of *twins*, it would seem that the weight of each twin is in general less than the average weight of *single children*, though their combined weight is greater. Dr Clarke found the average weight of twelve twins to be 11 lbs. avoirdupois a pair; the heaviest pair weighing 13 lbs., and the lightest $8\frac{1}{2}$ lbs. Mr Burns, however, states, that he has known instances, in which each twin was rather above than under the usual weight of a single child.

## PART II.

### OF THE ANATOMY IN GENERAL OF THE COMMON SYSTEMS AND COMMON TEXTURES OF THE BODY.

17. By the COMMON SYSTEMS of the body, we mean the *Circulating System*, the *Absorbent System*, and the *Nervous System*; and by the COMMON TEXTURES, *Cellular Substance, Adipose Substance, Muscle, Skin, Hair, Cartilage, Bone, Tendon, Serous Membrane*, and *Synovial Membrane*.

18. We have applied the term *Common* to these *Systems* and *Textures*, because they are common to many parts of the body.

A general view of their structure and distribution, forms a proper introduction to the anatomy of individual parts.

### ARTICLE I.

### OF THE ANATOMY IN GENERAL OF THE COMMON SYSTEMS.

#### I. OF THE CIRCULATING SYSTEM.

This system consists of two parts; *viz.* the *Heart* and the *Blood-vessels*.

#### 1. *Of the Heart.*

#### A. *The Heart of the Adult Male.*

The Oval Fossa.

19. When the cavity of the right auricle of the heart is laid open, we observe, on the lower part of its posterior surface, an elliptical, but very superficial depression, which slopes a little backwards, and is called the *oval fossa*. This fossa is about half an inch long, and the third of an inch broad, with smooth edges, and having its long diameter turned upwards and downwards. Its size, however, varies very much in different individuals, and frequently it is entirely wanting.

Several Continental anatomists have lately affirmed, that there is, in general, a small slit, sufficient to admit the point of a probe, immediately behind the upper margin of this fossa, which inclines upwards, and a little to the left, and opens into the left auricle. We have seen this passage only in a few instances; but the authorities are so respectable, by whom it has been said to occur in a majority of cases, that we cannot doubt the statement to be correct.

The Eustachian Valve.

20. The *Eustachian Valve* has not hitherto been described with sufficient accuracy. This is a thin, whitish, crescentic fold, situated immediately to the left of the opening of the inferior vena cava into the right auricle. Its posterior horn is connected with the left edge of the oval fossa, and its anterior with the right surface of the auricle, directly above the opening of the lower cava; so that it runs from behind obliquely forwards, and to the right. Its free curved edge looks upwards, and a little backwards; and one surface of it is continuous with the left and anterior side of the inferior cava, while the other is turned towards the left and fore part of the auricle. Were it prolonged straight upwards, it would run into the upper margin of the oval fossa; and, even as it is, when we look into the auricle from before, it cuts off from our view the lower half of this fossa. Its breadth and thickness vary extremely. Sometimes it is nearly half an inch broad, at other times scarcely perceptible; in some it is as thick as a wafer at its attachment, but tapering towards its edge, and without any holes in it; in others, it is as thin as silk-paper, transparent, and quite reticulated.

Capacity of the Cavities of the Heart.

21. In the heart, as we usually find it after death, the cavities of the ventricles always appear larger than those of the auricles. In general, also, the cavities of the right side appear to be more capacious than those of the left; the difference between them, however, being less in some cases than in others. In some instances they seem pretty nearly alike.

22. A variety of experiments have been made, with a view to ascertain precisely the capacities of these cavities after death; * but none of them can be regarded as quite satisfactory. In some, it is uncertain, whether precautions were taken to prevent the fluid employed in the measurement, from escaping by some of the blood-vessels communicating with the cavities. In others, it is doubtful whether certain coagula of blood, which generally form in these cavities after death, had been carefully removed; and in others, again, allowance is not said to have been made, for the extension of the cavities, which the weight of the fluid employed would necessarily produce.

In several experiments, in which we endeavoured to guard as much as possible against these sources of fallacy, we found, that the right ventricle of an adult heart contained two and a half ounces of water, while the left had only two ounces. Still, however, we are not disposed to place much reliance upon these, or any experiments of the kind.

Coats of the Heart.

23. The whole external surface of the heart is covered with *serous membrane*, which is thickest and strongest in the auricles.

Under this, at particular parts, is a quantity of *adipose substance*, which, shining through the serous membrane, gives the heart a straw colour at those parts.

Under both these is situated what is called the *muscular coat*; and within this, and lining the whole inner surface of the heart, is found the *inner membrane*.

The Inner Membrane.

24. This inner membrane in the cavities of the ventricles is as thin as silk-paper, perfectly transparent, and without the slightest appearance of fibres. Neither blood-vessels, absorbents, nor nerves, have yet been seen in it. Maceration in water renders it slightly opaque. It is easily detached from the muscular fibres which it lines, but no intermediate cellular substance can be seen between them. It is too tender to admit of being peeled off in large patches.

In the right auricle, the inner membrane lining the fleshy cords is quite similar to that in the ventricles; but in all other parts of this auricle, and over

* See Senac, *Traité*, &c. I. p. 189. Haller, *Elem. Physiol.* I. p. 323-7. Le Gallois, *Diction. des Scien. Medic.* V. p. 434.

the whole of the left also, it has a different appearance. It is whiter, and considerably thicker and stronger, than serous membrane. After slight maceration, it is disposed to peel in laminæ; but no fibres are perceptible in it, and, so far as we know, no one has yet seen in it, either vessels or nerves. It is firmly connected to the muscular coat by a fine cellular substance.

The Eustachian valve, and the valve of the coronary vein, appear to be formed of doublings of the inner membrane of the auricle. The former, however, generally contains a fasciculus of muscular fibres at its basis, which is included between the folds of the membrane.

Structure of the Tricuspid and Mitral Valves.

25. The structure of the tricuspid and mitral valves is not so simple. A delicate prolongation of the inner membrane of the auricles can indeed be traced over their inner surface; but we have never been able to detect any similar continuation of the membrane of the ventricles over their outer surface. They seem to consist of a fine but dense web of slender fibres continued from the tendinous cords. These cords, as their name imports, are composed of *tendinous substance;* and, after they have been inserted into the valves, they spread out and are interwoven in every direction, as may be easily seen by holding the valves between the eye and the light. It is the intersections of these cords, just after their insertion, that causes those knots and ridges which are so common on the valves, particularly on the mitral valve.

### B. *The Heart before Maturity.*

Shape of Fœtal Heart.

26. There is a considerable difference, in point of shape, between the heart of a fœtus and that of an adult, resulting from the greater proportional size of the tips of the auricles in the latter. In a fœtus of three or four months, these are so large, that they almost come into contact over the anterior part of the root of the pulmonary artery. As the fœtus grows older, however, they gradually diminish proportionally; so that after birth there is scarcely any peculiarity in this respect.

The Oval Hole of the Fœtal Heart.

27. The most striking and important peculiarity of the fœtal heart is the *oval hole* in the septum, between the auricles. This occupies exactly the situation of the oval fossa in the adult heart. The communication, however, between the auricles through it, is not direct. For, if we examine the heart of a fœtus about the fourth month, we shall find, that there is a thin pellucid membrane laid over the oval hole, like a valve, on the side next the left auricle. The insertion of this valve below, is into the very edge of the lower third of the oval hole itself; but above this, its attachment is into the surface of the septum next the left auricle; extending farther and farther out from the margin of the hole as it ascends. When it gets on a level with the upper border of the hole, it begins to incline inwards again, and, after running a short way, stops; leaving a free curved edge, turned upwards, and a little to the left.

As this valve, then, is longer than the oval hole, it is obvious that, if it were stretched tight across it, like the parchment of a drum, it would prevent all communication between the auricles. But it is twice as broad as the space included within the line of its insertion, so that it admits of being pushed a considerable way towards the cavity of the left auricle. When this is done, a short canal is formed, between the upper part of the valve and the portion of the septum immediately above the oval hole, opening into the left auricle by an orifice, of which the floating edge of the valve forms fully two-thirds. The axis of this canal corresponds exactly with the axis of the inferior vena cava.

Whether there be any period prior to the fourth month, at which the oval hole has no valve, or at which it is smaller, we have not had satisfactory means of ascertaining. But Haller (*Elem. Physiol.* VIII. Pars I. p. 375.) mentions, that his friend Bergen had found none in a fœtus of two months; and Senac (*Traité*, &c. Vol. I. p. 231.) believes that there is none prior to this at least, and expresses himself certain, that if its rudiments exist at two months, they are extremely small. After this period, according to him, it grows by degrees, and its margin approaches nearer and nearer to the upper border of the hole.

It is very probable that this description is correct; but, as we have found that the valve, even in the fourth month, is very easily broken, unless the heart be dissected with great care, nothing but actual observation will satisfy us on this point.

The hole and the valve remain pretty nearly in the state we have described, until about the commencement of the ninth month; when a considerable change begins to take place. The valve becomes thicker and tighter, and its free margin narrower; consequently the passage between the auricles becomes smaller. The sides of the hole itself are at same time thickened. The valve at last becomes so much tighter, and its upper border so much narrower, that the parts assume the appearance of the oval fossa, with a small slit at top, as already described. How long this process is of being completed, we have not ascertained; but we suspect, from an examination of several hearts, that it is not until two or three months after birth at least.

28. The Eustachian valve in the fœtal heart is subject to as much variety, in point of size, almost as in the adult. Eustachian Valve in the Fœtus.

29. The auricles of the fœtal heart are obviously larger, in proportion to the ventricles, than those of the adult; but the relative capacities of the right and left cavities, at this early period, have not been ascertained. They have generally appeared to us to be pretty nearly the same; or, if there was any difference between them, the left auricle and ventricle seemed rather the larger. Le Gallois has lately made some experiments on this subject (*Diction. des Scienc. Médic.* V. p. 440.); but they can hardly be regarded as satisfactory. Capacity of the Fœtal Heart.

## 2. *Of the Blood-Vessels in general.*

### A. *Of the Arteries in general.*

30. The arterial system of the human body resembles the trunks and branches of two trees. One trunk, called the pulmonary artery, arises from the right ventricle of the heart; and the other, denomi-

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nated the aorta, springs from the left ventricle. They are both about an inch and a quarter in diameter; and their sides are about a twelfth of an inch thick. Immediately after their origin they begin to ramify; and by successive ramifications of the branches, the whole body is at last supplied.

31. After the arteries have ramified to a certain degree of minuteness, they become so thin and transparent, that it is impossible to follow them, either with the naked eye, or with the microscope. In order, therefore, to render these very small vessels visible, anatomists inject into them thin coloured fluids, such as a weak solution of glue mixed with vermilion; and all our knowledge of the ultimate ramifications of arteries is derived from these injections.

Their Modes of Termination.

32. Some arteries are seen distinctly terminating in veins; others vanish from our sight; but in what manner they end is uncertain. The termination in veins, therefore, is the only one capable of demonstration; every other is matter of opinion.

Their Coats.

33. All arteries, which are not less than the twelfth of an inch, may easily be shewn to be composed of three coats, an inner, middle, and outer.

The inner Coat.

34. The inner coat resembles exactly the inner membrane of the ventricles of the heart. It is equally thin, and perfectly transparent and colourless; and its inner surface is smooth.. No vessels or nerves have yet been seen in it. It may be peeled off from the middle coat with the forceps; but it is too tender to separate in large patches. It differs from the inner membrane of the ventricles of the heart, in being a good deal more elastic.

The middle Coat.

35. The middle coat of an artery is the thickest; being about twice the thickness of the outer one. It consists of slender fibres laid closely together, side by side, without any apparent connecting medium, and placed uniformly in a circular direction, surrounding the artery, and in a plane perpendicular to its axis. Those which are more internally situated, may be easily seen through the transparent inner coat, when the artery is slit open; and if this coat be peeled off, the fibres of the middle one may be easily raised with the forceps in successive strips, all of which separate in a transverse or circular direction, exactly like the outer bark of a birch tree.

In the larger arteries, the fibres are of a yellowish or straw colour, and firm in their consistence; but, in the smaller vessels, they are softer and more flesh-coloured.

The outer Coat.

36. The outer coat of arteries differs extremely from the other two. It consists of slender, white, shining fibres, very dense and tough, closely compacted together, and interwoven in every direction. It is very difficult to separate them from each other, and impossible to make them peel in any regular manner.

37. Many arteries are surrounded with cellular substance externally; but this is merely an accidental covering. It is not a necessary part of the arterial tube; and cannot, therefore, with propriety be described as one of the coats of an artery.

38. In arteries which are less than the twelfth of an inch, it is not easy to distinguish the different parts which compose them. But there is every reason to believe that they have the same structure as the larger vessels.

### B. *Of the Veins in general.*

39. The distribution of the veins throughout the body, like that of the arteries, resembles the ramification of a tree; but, in describing them, it is usual to invert the order observed in tracing the arteries, and to consider the trunks as successively formed by the union of the branches.

Their Origin.

40. When we apply the microscope to a thin or transparent part of the body, which has been properly injected, we can perceive many of the most minute veins, arising from the extremities of equally minute arteries, and distinctly continuous with these. Any other origin of veins than this is quite uncertain.

Their Valves.

41. Many of the larger veins, and veins of middle size, are provided with valves. These are membranes of a semilunar shape, perfectly transparent and colourless, and though scarcely the thickness of a hair, yet very dense and strong. They are attached by the whole of their curved margin to the inner surface of the vein; and this margin is uniformly turned towards the branches of the vein, while their free straight edge looks towards the trunks. They are inserted into the sides of the vein in such a manner, as to be in a certain degree loose within the tube; and, accordingly, when any fluid is forced from the trunks towards the branches, they are pushed inwards from the sides of the vessel towards its axis. They vary very much in their dimensions, even in vessels of the same calibre. Sometimes they occur single, particularly in the smaller vessels; sometimes, though very rarely, three are found together; but, in general, they are disposed in pairs, one exactly opposite to the other. They are very seldom so large, or so precisely adapted to each other, as to shut up the tube of the vessel completely. The number of them occurring either singly or in pairs, within any given extent, is very various in different veins. They are found at intervals of from four or five inches to a quarter of an inch, or even less. In general, they are most numerous in veins of small size.

Their Coats.

In all veins that are not less than a twelfth of an inch in diameter, two coats can be distinctly demonstrated; and in some, portions of a third texture intervene between these two.

Their inner Coat.

42. The inner coat of veins is transparent like that of arteries. It is a little thick r, however, and greatly stronger; and it differs also from the inner coat of arteries in this, that it can be distinctly separated into slender dense fibres.

Their outer Coat.

43. The outer coat of veins has the same structure as the outer coat of arteries. It is thinner, however, proportionally, and its fibres are not so close.

Their partial middle Coat.

44. In almost all the trunks and larger branches of veins, a substance is found intervening between these two coats; sometimes surrounding the vein entirely, but in general occurring in patches of different sizes. It varies a good deal in its thickness; being as thick in some parts as the outer coat, and only

half as thick in others. It seems to be of a texture intermediate between the external and middle coat of an artery.

### II. OF THE ABSORBENT SYSTEM.

45. The Absorbent System of the human body consists of *Absorbent Vessels* and *Absorbent Glands.*

#### 1. *Of the Absorbent Vessels in general.*

Their Terminations.

46. The absorbent vessels are a system of tubes, distributed throughout the body in the manner of the blood-vessels. They are described in the same manner as the veins. Exceedingly minute at first, they unite one with another, and at last form two trunks, each about a quarter of an inch in diameter, which open into two veins called *subclavio-jugular veins*, one on each side of the neck; the left trunk being denominated the *thoracic duct*.

Their Origins.

47. There is no part of the body, in which the absorbent vessels can be traced to their beginnings with the naked eye. Cruikshank was fortunate enough, in one case, to find the absorbents of the alimentary canal so turgid with a milky substance after death, that, with the microscope, he could distinctly trace hundreds of them to their origins, which had the appearance of circular orifices, (*Anat. of Absorb. Vessels*, p. 56.) But this is the only part of the body, in which the commencements of these vessels have been seen, even with the microscope.

Their Structure.

48. Little is known respecting the structure of the absorbent vessels; they are too delicate to admit of satisfactory dissection. We have examined, however, pretty minutely, the thoracic duct; and it seems to us to consist of one coat only. This resembles the inner coat of veins; and the valves of the absorbents appear to be merely prolongations of it.

#### 2. *Of the Absorbent Glands in general.*

49. These bodies may be regarded as consisting of a peculiar *substance* enclosed in a *capsule.*

50. We are inclined to regard Mascagni's description of the structure of the former, as by far the most accurate which we yet possess. (*Vas. Lymph. Hist.* p. 30.)

Structure of their Substance.

51. According to this very respectable authority, the vasa inferentia, before entering a gland, divide into branches. Some of these penetrate directly into the central parts of its substance, while others are distributed towards the surface. The larger branches are bent, convoluted, and interwoven, in every direction; they communicate freely with each other; and become suddenly narrow in some parts, while they swell out into little cells at others; so that when the gland is injected with quicksilver, its whole outer surface seems as if covered with little rounded eminences. The smaller branches subdivide, and form a net-work on the surface, and then either dip down between the cells of the larger ones, or open into them. Various small vessels, on the other hand, are seen, either arising from these cells, or ascending from between them, and after winding about, uniting together into larger branches, which at last constitute the vasa efferentia.

Sometimes the absorbent vessels of a gland preserve a pretty uniform diameter throughout; so that there is little or no appearance of cells in any part of it.

Their Capsule.

52. The capsule of absorbent glands is a thin, pellucid, and colourless membrane, very vascular, and resolvable by maceration into fine whitish fibres.

### III. OF THE NERVOUS SYSTEM.

53. The Nervous System may be divided into two parts; the *Central Mass*, and the *Nerves.*

#### 1. *Of the Central Mass.*

54. The central mass of the Nervous System is composed of the *Brain* and the *Spinal Cord.* We shall offer a few remarks on each of these separately.

#### A. *Of the Brain.*

##### a. *The Brain of the Adult Male.*

55. The brain weighs, in general, about $2\frac{1}{2}$ lbs. or 3 lbs. avoirdupois. Both its weight, however, and its volume, vary a little in different individuals; but without any fixed relation to the weight or stature of the individual.

56. It is almost symmetrical; its median plane corresponding to the median plane of the whole body; so that it is divisible into two halves, right and left, very nearly alike.

57. It is usually regarded as consisting of two parts; an upper part, denominated the *Brain Proper*, and a lower one, called the *Cerebellum.*

58. The brain proper weighs in general from 35 to 45 oz. and the cerebellum from 5 to 8 oz. avoirdupois.

59. The brain is composed almost entirely of a peculiar substance, which we shall call *nervous matter*, embraced by delicate *membranes.*

##### *α. The Nervous Matter of the Brain.*

60. There are two kinds of this matter; the one usually denominated medullary, and the other cineritious. We prefer, however, to distinguish them by the terms *white* and *brown.*

The White Nervous Matter.

61. The white nervous matter is of different shades, in different parts of the brain. In most parts, its colour resembles a mixture of orange-white, and wine-yellow (see Syme's *Nomenclature of Colours*); and this kind we shall call orange-white. In others, it approaches more nearly to the wine-yellow; and this species may be denominated yellowish-white.

Its Consistence.

62. The consistence of the white nervous matter varies a little in different parts. In general, it is less elastic than jelly, but somewhat more glutinous or viscid.

Appearance when divided.

63. When we make a section of it in any direction, with a sharp scalpel, it appears perfectly smooth, and of a uniform colour. A few reddish points and striæ may be observed here and there; but there is no appearance whatever of cells, or globules, or fibres.

Microscopical Appearance.

64. It has been subjected to very minute microscopical examination by Prochaska. (*Oper. Min.* Pars I. p. 342.) When he took a small portion of it, either from the brain proper or the cerebellum, and spread it on a thin plate of glass, so that it became pellucid, and then examined it with a powerful microscope, he

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found that it resembled a sort of pulp, consisting of innumerable globules, or particles of a roundish form. A little water added to this pulp, divided it into a number of flocculi; but he observed that each flocculus was still composed of a number of globules. He very rarely found one globule by itself, or even two, floating in water, apart from the rest. Maceration in water, even for three months, was insufficient to separate them from each other. He concluded, therefore, that they were united by means of a very delicate and pellucid cellular substance The globules, he observed, were not all of the same size; but varied a little in dimension, even in the same part of the brain. In general, however, he found them, both in the brain proper and in the cerebellum, to be more than eight times smaller than a globule of the blood. The most powerful microscopes did not enable him to discover anything satisfactory respecting their structure.

65. These observations have, within these few years, been prosecuted, on a much more extensive scale, by Joseph and Charles Wenzel. (*De Penitior. Struct. Cereb.* p. 24.) They have uniformly found that the white nervous matter seemed as if entirely composed of extremely small globules, or corpuscules of a roundish form, putting on the appearance of little cells, filled with proper medullary substance.

No estimate is given of the dimensions of the globules; but they describe them as being exceedingly minute, and as being all pretty nearly of the same size. They seemed to adhere very closely to each other, without any apparent connecting medium. The globular appearance continued distinctly perceptible, in portions of the substance, which had been long exposed to the action of rectified spirit of wine and muriatic acid; nor was it even destroyed by steeping the matter in alcohol, and then drying it.

Its Blood-vessels.

66. White nervous matter possesses considerable vascularity. The arterial branches, however, which supply it, are seldom much larger in diameter than a common pin; and the veins are for the most part equally small. It is the division of blood-vessels which produces the appearance of red points and red striæ in this matter, when incisions are made through it.

Effects of Coagulation on it.

67. When a portion of white nervous matter has been immersed in boiling oil for a few minutes, or steeped for a few days in alcohol, or diluted muriatic or nitric acids, or a mixture of alcohol and acids, or a solution of corrosive sublimate, its consistence is greatly increased; and if we tear it into fragments, we find that the surfaces of the fragments exhibit a fibrous appearance. White threads, as slender as a hair, may be raised from these surfaces with the point of a pin; and the whole substance seems to be formed of such fibrils placed close to each other. The delicacy of these threads, and the closeness with which they are compacted together, render it quite impossible to ascertain their actual length, or even to form a conjecture as to the extent to which they may be subdivided.

Whether the white nervous matter in all parts of the brain be susceptible of this change on coagulation, does not seem to us satisfactorily established.

Its Chemical Properties.

68. In the chemical analyses which have hitherto been made of the nervous matter, the white species does not seem to have been distinguished from the brown. This circumstance deserves to be attended to, in reading the fullest analysis of the nervous matter which has yet been made, viz. that by Vauquelin. (*Annal. de Chim.* Tom. LXXXI.)

The Brown Nervous Matter.

69. The brown nervous matter varies a little in its hue also. Its most common colour is wood-brown; but sometimes it is like a mixture of wood-brown and lead-grey; and this last colour we may call greyish-brown.

70. It is softer than white nervous matter, and in many parts is more vascular. It exhibits the same appearances, however, when divided with the scalpel; and seems to be composed of similar globules when examined with the microscope. In certain parts, too, of the brain, we have found, that when coagulated by boiling oil, or acids, &c. it appears fibrous on laceration; but whether or not the brown matter generally be susceptible of this change, we have not ascertained.

Distribution of the White and Brown Nervous Matter.

71. These two kinds of nervous matter, the white and the brown, are intermingled within the brain in various ways. In some parts, a covering of the one surrounds a mass of the other, as a capsule encloses a nucleus; in others, they are alternated in laminæ or strata; and in others, they traverse each other in the form of cords or fibres of various sizes. Yet, notwithstanding this diversity in their arrangement in different parts, their disposition in each particular part is observed to be remarkably uniform.

72. The only attempt, worthy of notice, which has yet been made to represent the proportions and arrangement of those two kinds of matter in the brain, in a series of coloured engravings, is that by Vicq d'Azyr, in his folio work, entitled *Traité d'Anatomie et de Physiologie*, published at Paris in 1786. The chief merit of this work, however, consists, not in the engravings themselves, which are seldom entitled to the praise of accuracy, either in point of form or colouring, but in the minute explanations and details which accompany them.

73. There are peculiarities in the structure of the pituitary gland and pineal gland, which deserve to be farther investigated.

The Pituitary Gland.

The pituitary gland is a good deal firmer than the other parts of the brain, and seems to be intersected by a texture different from common nervous matter. When it is pressed between the fingers, the nervous matter appears as if it were forced out of a sponge. In general, two distinct masses may be perceived in it; one occupying the fore part, approaching rather to purple in its colour; and another behind, softer in its consistence, and of a lighter hue.

The Pineal Gland.

74. The pineal gland also contains two substances very different from each other. One is a matter somewhat like brown nervous matter, but softer than that matter generally is; and the great bulk of the gland is made up of this substance. The other is like grains of sand, consisting of hard, semitransparent, yellowish particles, varying a little in size, but seldom larger than the head of a pin. Sometimes these particles are grouped together into a heap or acervulus on the upper surface of the gland, close to its base; at other times they form a sort of chain

or ridge along its margin; and at other times again they are irregularly scattered through its substance. There is the greatest variety in their number. In two or three instances, after the strictest search, we have not been able to find more than a single particle within the whole gland. We have made a few chemical experiments on these particles, and are rather inclined to think that they have the same composition as bone.

*β. The Membranes of the Brain.*

75. The membranes of the brain are two in number, the *Pia Mater* and the *Arachnoid Membrane.*

** The Pia Mater.*

76. All the arterial vessels which enter into the composition of this membrane, seem destined ultimately to supply the nervous matter of the brain; and this matter appears to derive arterial vessels from no other source. The same remark applies to the veins of the pia mater; so that we may regard this membrane as a vascular covering formed of blood-vessels, which are just about to penetrate the nervous matter of the brain; and of blood-vessels which have just emerged from it.

77. After a minute injection, it is difficult to perceive anything in the pia mater but blood-vessels; and these are interwoven in every direction. We have not yet been able to discover any absorbents or nerves in it. There is an appearance of very fine dense white threads in it, at particular parts, where it happens to be but loosely connected to the arachnoid membrane; but it is uncertain whether these are not blood-vessels. We cannot perceive any cellular tissue in it, such as Bichât has described, *Anat. Descrip.* III. p. 27.

*** The Arachnoid Membrane.*

78. This differs very much from the former, both in structure and distribution.

It is as thin as a cobweb, dense, colourless, and almost perfectly transparent. Its outer surface is quite smooth; its inner, more or less thready or flocculent, according to its connection with the pia mater.

Nothing is known respecting its structure. We have never seen blood-vessels in it, either in its healthy or diseased states, with or without previous injection. It has hitherto proved equally impracticable to demonstrate in it either absorbents or nerves. Bichât classes it with the serous membranes (*Anat. Descrip.* III. p. 32.); but it is so little analogous to these in point of structure, that we prefer to regard it as a peculiar membrane.

b. *The Brain of the Adult Female.*

79. It has been often affirmed that the brain of the female differs from that of the male, slightly, both in form and dimensions. We cannot say, however, that we are satisfied of the truth of this observation. The point requires to be further investigated.

c. *The Brain before and after Maturity.*

80. On this subject, hardly anything satisfactory was known, until within these few years.

81. We have already had occasion to refer to a work by the Wenzels, entitled *De Penitiori Structura Creberi Hominis et Brutorum*, which was published, in folio, at Tubingen, in 1812. We strongly recommend this treatise to the attention of our readers. It appears to us the best and most original work on the structure of the brain, which has appeared for more than a century. The authors seem to have employed themselves, unremittingly, in investigations relating to the anatomy of this organ, for upwards of twelve years, and in circumstances singularly favourable for observation. There is little of importance relative to the state of the brain at different periods of life, at present known, for which we are not indebted to their labour and ingenuity.

82. From a variety of facts, which our limits will not permit us to give in detail, we select the following respecting the dimensions and weight of the brain, which seem to be the results of an immense number of observations.

83. First, with respect to dimensions, they find that both the brain proper and the cerebellum increase rather more in length and in breadth, during the six months immediately preceding birth, than during the first seven years after birth; that these dimensions arrive at their maximum at the age of seven; and that they suffer no change during the whole of after-life. Its Dimensions.

84. Secondly, with regard to weight, they ascertained, that the weight of the whole brain, most commonly arrives at its maximum, at the age of three years, and remains without diminution, during the whole of after-life; the maximum being in general from 20,000 to 22,000 grains, and seldom exceeding 24,000. The weight of the brain proper, at the age of three years, they found, does not exceed, in general, 21,000 grains; nor that of the cerebellum 2000 grains. The younger the fœtus, they observed, the greater was the ratio of the weight of the brain proper to that of the cerebellum. This ratio, it appeared, was usually about seven to one, at the age of three years, and remained so ever after. Its Weight.

B. *Of the Spinal Cord.*

a. *The Spinal Cord of the Adult Male.*

85. We regard the spinal cord as beginning at the lower margin of the annular protuberance of the cerebellum. The arrangement which includes a portion of its upper extremity, along with the brain, under the name of medulla oblongata, seems to us neither so precise nor so natural.

86. From a few actual measurements of it, we are inclined to think, that its length, in general, is about thirty inches. Chaussier says, its weight is from about a nineteenth to a twenty-fifth of that of the whole brain. (*Exposit. Sommaire*, p. 119.) Its Length and Weight.

87. Like the brain, it consists of *nervous matter*, enclosed in *membranes.*

*α. The Nervous Matter.*

88. This differs very little, apparently, from that of the brain. The cord contains both kinds of it.

89. The white matter is chiefly of the orange-white species, and is firmer than the same kind of substance in any part of the brain, except the annular protu-

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berance. The brown matter is chiefly of the greyish species.

90. The nervous matter does not extend the whole length of the cord; it ceases within nine inches of its extremity, and the membranes alone form the rest.

Divided into Three Portions.

91. It may be divided into three portions. The first portion may be called the top of the cord or cranial portion, and is about an inch in length. This is what is denominated by many the medulla oblongata. The second is about five inches in length, and may be denominated the cervical portion; and the third, which is about fifteen inches long, we shall call the dorsal portion.

92. The arrangement of the two kinds of nervous matter in the cord, has not hitherto been described or represented with sufficient accuracy. The whole of the cervical and dorsal portions, and the lower part of the top of the cord, consist of a central column of greyish-brown matter, surrounded by a stratum of orange-white. The upper half of the top, contains a much larger proportion of white nervous matter, than any other part of the cord.

Rendered Fibrous by Coagulation.

93. We have found that considerable portions of the nervous matter of the cord, are rendered fibrous in the longitudinal direction by coagulation.

*β. The Membranes.*

94. The Membranes of the spinal cord are three in number; the *Pia Mater*, the *Serrated Membrane* or *Ligamentum Dentatum*, and the *Arachnoid Membrane*.

It will be necessary only, on the present occasion, to say a few words with respect to the second of these.

The Serrated Membrane.

95. The serrated membrane is whitish and semi-transparent in its appearance, and thinner than the pia mater, yet fully stronger. Its inner border, which is straight, is intimately connected with the pia mater; while its outer one presents a series of angular projections or teeth, each of which is attached firmly to the dura mater of the spinal canal.

96. In its internal structure, it most resembles the substance called tendon.

97. It begins at the top of the cervical portion of the cord, and ends, in general, just where the swelling commences on the lower part of the dorsal portion. After it has terminated, a very slight ridge may be seen running down from it, on the surface of the pia mater, and exactly in the same direction, for about an inch and a half. We have never seen it, however, reach the extremity of the cord.

b. *The Spinal Cord of the Adult Female.*

98. We are not acquainted with any material circumstances in which the spinal cord of the female differs from that of the male; but, according to Chaussier (*Exposit. Som.* p. 117.), its nervous matter is softer.

c. *The Spinal Cord before and after Maturity.*

99. The nervous matter of the cord has been said to be proportionally shorter in the child than in the adult; but this has not been established.

100. Chaussier concludes, from a great many observations, that this matter is firmer at birth than at any other period of life, and that it gradually becomes softer as the individual advances in years. We suspect some fallacy in this remark.

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101. We are inclined to think, that the central column of brown nervous matter in the cord, is larger proportionally, and darker in its colour, at birth, than at any after period of life. We have often observed, in old persons, that it had entirely disappeared; its place being occupied by white matter; and we find that Chaussier states this to be a constant occurrence in the decline of life. (*Exposit. Som.* p. 146.)

2. *Of the Nerves.*

102. The nerves are cords of a peculiar structure, connected either directly, or indirectly, with the central mass.

Their Mode of Distribution.

103. There is the utmost variety in the mode of their distribution. Many of them may be seen spreading themselves out by regular ramification. Others divide into branches, and then soon after unite into trunks again. Others may be traced into a net-work or *plexus*, formed of various nerves interwoven in every direction, but in which each individual nerve is in a manner lost; and which sends off new branches to be expended by new ramification, or to unite with new plexuses. There is but one nerve in the body which neither exhibits ramification, nor is connected with any other nerve by plexus throughout the whole of its course. This is the optic nerve.

Plexus.

Ganglion.

104. At the union of two or more nervous branches with each other, certain knots or tumours frequently present themselves, which have been called *ganglia*; and the same name has been extended to similar swellings, which very often occur on single nerves. These *ganglia* are of various shapes and sizes; none of them exceeding three quarters of an inch, or an inch.

Nerves divided into Primary and Secondary.

105. Many nerves are attached directly to the central mass; and in such cases, the extremity of the nerve which happens to be connected to the brain or spinal cord, is invariably considered as its *origin*. We propose to denominate all those nerves which have such an origin, *primary nerves*. Those which take their origin in plexuses, or ganglia, or in other nerves of which they constitute branches, we may call *secondary nerves*.

106. The primary nerves communicate, more or less intimately, with all the secondary nerves, by means either of ramification, or plexus, or ganglion. Hence, all the nerves in the body are said to be connected, either directly or indirectly, with the central mass of the nervous system.

Structure of Nerves.

107. Nerves are composed of filaments of nervous matter enclosed in sheaths of a peculiar substance, hence called *neurilema*. The structure and arrangement of these were first well described by the late Professor Reil. (*Exercitat. Anatom.* Fascic. Prim.)

108. The filaments of nervous matter are of different sizes in different nerves, and sometimes even in the same nerve. They seldom, however, exceed the thickness of a hair; and in most instances, are smaller than the finest fibre of silk or cotton, so that it requires a microscope to see them distinctly. They are placed side by side; and in their course, divide, and subdivide, and reunite, and run into each other, forming the most intimate connection. The greater

number of the nerves in the body, consist of several separate fasciculi of these filaments; some of only one fasciculus.

109. The neurilema, or substance which surrounds each filament, and ties the filaments into fasciculi, &c. is, in most instances, so like cellular substance, that we may regard it as a species of that texture.

Structure of Ganglia.

110. Scarpa's description and representations of the structure of the ganglia, are by far the most accurate which we yet possess. (*Anatom. Annotat.* Lib. Prim.) There is a good deal, however, connected with this subject which requires to be farther investigated.

111. In these bodies, the fasciculi of nervous filaments attached to them, suffer a temporary subdivision and separation from each other, and are then combined anew. The intermixture of fasciculi which takes place within them, is in general so intimate, that it looks as if every fasciculus of every nerve, which emerges from a ganglion, contained more or fewer filaments from every fasciculus of every nerve which entered it.

112. Each fasciculus, in its progress through a ganglion, seems to be provided with its proper neurilema. But, besides this, the spaces left between the intersections of the fasciculi, are filled up with a peculiar soft substance, of a greyish, sometimes a yellowish, colour. This substance does not seem to us to have the slightest resemblance to the brown nervous matter of the brain and spinal cord; although it has been very confidently pronounced to be the same by some anatomists. Scarpa regards it as a peculiar cellular substance, filled with a mucilaginous or oily matter.

Enumeration and Classification of Nerves.

113. There are eighty-four primary nerves in all; forming forty-two pairs. The nerves of each pair arise, one from each half of the central mass, at corresponding points.

114. Some of these arise from the brain, others from the spinal cord; they may, therefore, be divided into *cerebral* and *spinal*.

115. There are eight pairs of cerebral nerves. These are the following:

The Olfactory nerves.
The Optic nerves.
The Common Oculo-muscular nerves. *
The Internal Oculo-muscular nerves. †
The External Oculo-muscular nerves. ‡
The Trigeminal nerves. §
The Facial nerves. ||
The Auditory nerves. ¶

116. There are thirty-four pairs of spinal nerves; and, these are:

The Glosso-pharyngeal nerves.
The Pneumo-gastric nerves. **
The Hypo-glossal nerves. ††
The Accessory nerves. ‡‡
The Sub-occipital nerves.
The Cervical nerves, - Seven pairs.
The Dorsal nerves, - Twelve pairs.
The Lumbar nerves, - Five pairs.
The Sacral nerves, - - Five pairs.

117. We have purposely avoided applying any numerical appellations to the primary nerves, which arise from the brain, and the top of the spinal cord; in order that there might be the less risk of their being mistaken by those who have long been accustomed to the old, but very inaccurate, numerical nomenclature.

## Article II.

### OF THE ANATOMY IN GENERAL OF THE COMMON TEXTURES.

### I. THE ANATOMY IN GENERAL OF CELLULAR SUBSTANCE.

118. From the term *cellular*, which has long been applied to this texture, one would naturally be led to suppose, that it was a substance formed into cells, admitting of easy demonstration. But this is far from being the case. In a mass of it, examined with the microscope, we can perceive nothing but exceedingly delicate fibres, interwoven in every direction. It is only when it is distended, or when we endeavour to tear its parts asunder, that it exhibits a cellular appearance.

119. If we lay hold of a mass of it between the fingers, and pull it gently, it immediately separates itself into innumerable transparent laminæ, finer than the finest cobweb, which intersect each other in every direction, and leave spaces or *cells* between them of various shapes. The same effect may be produced, by inserting the point of a blow-pipe into the midst of the substance, and blowing into it; or by an injection of water, or any thin fluid. In proportion as we pull or distend the substance, the smaller laminæ successively give way, and several cells are thus united into one; until at last the whole are torn. The instant the distention is discontinued, the parts collapse, and the cellular appearance vanishes.

120. It remains, therefore, to be determined, whether this substance consists, in its natural, undistended state, of numberless fine laminæ, of a definite size and form, closely applied to each other; or whether the cells which it exhibits, when distended, be not merely the effect of the accidental separation of layers of the substance, always accompanied with greater or less laceration of parts, and of course varying with the direction and degree of the distending force.

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* Synonym. *Lat.* Motores communes oculorum.

† Synonyms. The fourth pair, according to the old enumeration. *Lat.* Nervi pathetici.

‡ Synonym. *Lat.* Abductores oculorum.

§ Synonyms. The fifth pair, according to the old enumeration. *Fr.* Les nerfs trifaciaux.

|| Synonym. The portio dura of the seventh pair, according to the old enumeration.

¶ Synonym. The portio mollis of the seventh pair.

** Synonyms. The eighth pair of cerebral nerves, according to the old enumeration. *Lat.* Par vagum; nervi vagi. *Fr.* Les nerfs vocaux.

†† Synonym. *Fr.* Les nerfs linguaux.

‡‡ Synonyms. *Fr.* Les nerfs spinaux; les nerfs spino-cranio-trapeziens.

121. Bichât has devoted a long chapter of his *Anatomie Générale* to the description of this texture. (Tom. I. p. 11.) It contains a great deal of matter, however, which is quite foreign to the subject; and, in other respects, is often vague and incorrect.

The most original remarks on this substance are to be found, in a paper by the celebrated Dr William Hunter, in the second volume of the *Medical Observations and Inquiries.*

### II. THE ANATOMY IN GENERAL OF ADIPOSE SUBSTANCE.

122. This texture is obviously composed of two distinct substances; an oily matter, and a vascular texture formed into cells, in which this matter is contained.

123. The oily matter possesses all the characters of the fixed oils. It seems to us most probable, that it exists in the living body in a fluid state. We are led to entertain this opinion chiefly from some experiments, in which we raised portions of the adipose texture taken from the dead body, to the temperature of the living. But we have further observed, in surgical operations, that, when a thick portion of adipose substance happens to be divided, minute globules of oil may be seen swimming, in great abundance, in the stream of blood that flows from the wound.

124. The vascular texture which contains the oily matter, appears to be composed of a substance fully more delicate than cellular substance, and to consist of little spherical cells placed closely together side by side. These cannot be distinctly seen without a magnifying-glass. They vary a little in their size, but are all exceedingly minute. According to Dr Monro, none of them exceed the eight-hundredth part of an inch, nor are less than the six-hundredth. (*Descrip. of the Bursæ Mucosæ.*)

The cells of adipose substance have no resemblance whatever to the cells formerly described in cellular substance.

### III. THE ANATOMY IN GENERAL OF MUSCLE.

125. Muscle seems to be composed of delicate fibres of a peculiar nature, surrounded and united together by a substance like cellular substance; and supplied with blood-vessels, absorbents, and nerves.

126. Prochaska's description of the fibres is still not only the most accurate, but the clearest which we possess. (See *Oper. Min.* Pars I. p. 160.)

127. According to this author, muscle in all parts of the body may be resolved by careful dissection into fibres of great delicacy, but pretty uniform in form and general appearance, as well as in dimensions. Their diameter does not seem to exceed the forty-thousandth part of an inch; and although they are very variable in their length, some of them, it would seem from Prochaska's observations, extending nearly three feet, they preserve the same diameter throughout. They seem all more or less flattened or angular, and have no appearance of hollowness, but are solid diaphanous filaments. Prochaska seems to have no doubt that these fibres, or *fila carnea*, as he calls them, are incapable of farther division. On this supposition we may call them the *primary muscular fibres.*

128. The *primary fibres* are placed parallel and close to each other, and in every species of muscle, it would seem, are united, in the first place, into fasciculi of a certain size. These, in a transverse section, always appear polyedrous; and in the representation which Prochaska has given of them, as seen through a microscope magnifying the diameter two hundred times, the largest of them does not exceed an eighth of an inch, and the smallest is not below a sixteenth. In point of length they are various; but Prochaska affirms, that he has traced them extending, unbroken, and unconnected with any other fasciculi, from one end to the other of the *sartorius muscle*, which is one of the longest in the body.

129. These fasciculi, which we may call *primary*, are generally found united together into longer fasciculi; which may be denominated *secondary*, and these often into *ternary*, and so on.

130. A chemical analysis of human muscle is still a desideratum.

### IV. THE ANATOMY IN GENERAL OF SKIN.

131. Except the mouths of the sebaceous follicles, we do not believe that any pores are visible on the external surface of the skin, either with the naked eye or with the microscope. We can perceive no appearance of them even at the points from which the hairs spring; the hairs seem to fill up completely the canals through which they pass.

132. The inner surface of the skin, in almost all parts of the body, exhibits a number of depressions, varying in size from a twelfth to a tenth of an inch or more, producing a sort of areolar appearance.

133. The skin consists of two substances, placed one above the other, in the form of layers or laminæ. The inner lamina is called *true skin*, the outer, *cuticle, epidermis*, or *scarf-skin.*

134. We have found that the best and easiest mode of separating these two from each other, for particular examination, is to preserve a piece of skin, either on the recent subject or detached from it, carefully from moisture, but not so as to render it dry and hard. At the end of a week, or ten days, or more, according to the temperature of the air, such a degree of decomposition has in general taken place between the cuticle and true skin, as enables us to separate the former, with the slightest oblique pressure with the point of the finger.

135. The intimate structure of the true skin is quite peculiar. It seems chiefly made up of a species of very small dense fibres, somewhat resembling the fibres which compose the outer coat of an artery, which are closely interwoven with each other, and more firmly compacted together the nearer they are to the outer surface.

136. The outer surface of the true skin is more vascular than the internal parts; and this surface seems to owe its colour entirely to the blood circulating in its vessels.

137. The absorbent vessels of the true skin are so large and so numerous, that after they have been injected with mercury, the outer surface exhibits an exceedingly minute net-work of tubes. We

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have never seen, however, the smallest particle of the quicksilver escape from the outer surface, even in the most minute injections.

The Cuticle.

138. The *cuticle* is transparent, and of a slightly yellowish-grey colour. The colour of the outer surface of the true skin is, therefore, seen through it; and we have no doubt that the colour of the surface of the body, in the inhabitants of this country, and of Europe in general, depends entirely on the colour of the outer surface of the true skin, blended with the slight tinge of grey from the cuticle.

139. In almost all persons in health, there are certain parts of the soles of the feet, in which the epidermis is divisible into layers; but this seems to be purely the effect of compression; which accumulates into a thick stratum those portions of the cuticle which are constantly separating from its surface, and which, in other parts of the body, are immediately removed. This laminated appearance is never seen in the soles of persons who have been long confined to bed, or in those who, from accident or disease, have not been able to put the foot to the ground. The cuticle, in other parts of the body, does not exhibit the slightest appearance either of laminæ or fibres.

140. This part of the skin is entirely destitute of blood-vessels, absorbents, and nerves. It is truly a *non-vascular* part, like the enamel of the teeth.

141. It is well known that when a piece of cuticle is plunged into pure nitric acid, it instantly acquires a yellow colour. In the course of twenty minutes or so, we have found, that it becomes thicker, softer, and more opaque; in twenty-four hours it is reduced to a yellowish pulp; and in about a month or six weeks it is almost entirely dissolved. Pure muriatic acid acts upon it somewhat in the same way; but less powerfully, and less speedily. Pure sulphuric acid immediately gives it a deep brown colour; in the course of twenty hours, renders it thicker and more elastic; and, after the lapse of several weeks, reduces it to the state of a very thin deep brown pulp.

Black Membrane.

142. We have satisfied ourselves, by a variety of dissections, that there is in the Negro, Caffre, and Malay, a *black membrane* interposed between the epidermis and the true skin, upon which the dark colour of these people entirely depends. This membrane sometimes peels off with the cuticle, and sometimes adheres to the true skin. It is more tender than the cuticle, and thinner; but, like it, is entirely without vessels, and without any appearance of holes, or plates, or fibres. We conclude, that in all black men there is a similar membrane, to which their dark colour is owing.

Rete Mucosum.

143. After the strictest examination, however, we have not been able to discover any light-coloured membrane or pigment, such as has been described under the name of *rete mucosum*, between the cuticle and true skin, in the inhabitants of this country, nor in those of other European nations resembling them in colour. We have sought for it in every way, but without success. We are disposed, therefore, to deny its existence. The cause of the light colour of the skin in fair people has been already explained. (Sect. 138.)

144. Whether there be any brownish membrane in tawny people, like the black membrane in the negro, we have had no opportunity of ascertaining.

### V. THE ANATOMY IN GENERAL OF HAIR.

145. We call the *root* of a hair, not only that part of it which is contained in the bulb, but the portion which is lodged in the skin. The *middle part* and the *point* are the parts which project beyond the surface of the skin.

146. All the hairs in the body seem to be cylindrical, and taper regularly from the root to the point.

147. Of whatever colour they be, the root is always whitish, and transparent, particularly that part of it which is lodged in the bulb. This part, too, is always much softer than the rest; the very extremity being almost fluid.

148. As far as we can judge from microscopical observations, the hairs seem to be quite solid. We have never seen any appearance of cells, or canals, or laminæ, or fibres, in any part of them. In the whiskers of the seal, however, the part of the root of the hair which is lodged in the bulb, contains a conical cavity: and we suspect it is the same in human hair.

149. Dr Brewster has ascertained that hairs depolarise light, and possess the most perfect neutral axes; the axes being parallel and perpendicular to the axis of the hair. (*Phil. Trans.* 1815.)

150. The chemical properties of hair have been very minutely investigated by Vauquelin. (See *Annales de Chimie*, Vol. LVIII. and *Nicholson's Journal*, Vol. XV.)

151. Judging by analogy, from the structure of the *bulbs* of those large hairs which form the whiskers of such animals as the seal, we should imagine that the *bulbs* of the human hairs consisted of two coats or tunics; an inner one of a tender consistence, very vascular, and embracing immediately the root of the hair; and an outer, firmer, and less vascular one, closely surrounding the former.

152. The bulbs of the hairs are always situate under the true skin; but so close to its inner surface, that no part of the hair is perceptible between it and the bulb. Immediately after leaving the bulb, the hair is received into a canal in the true skin, which is constantly observed to be more or less oblique. A small hole in the cuticle corresponds to this canal; and the hair passing through it also, reaches the outer surface of the skin. In its passage through the true skin, we believe that it adheres to the sides of the canal, just as epidermis would do.

### VI. THE ANATOMY IN GENERAL OF CARTILAGE.

153. On careful examination of this substance with the microscope, it appears to us to be uniform and homogeneous in its structure, like jelly, and without fibres, or laminæ, or cells.

154. In its purest form, no blood-vessels are seen in it, nor can they be injected even with the finest colouring matter. In those pieces of cartilage, however, which are attached to the edges or extremities of growing bones, blood-vessels of considerable size may often be seen ramifying, even without the aid of injection.

155. The chemical properties of cartilage have not yet been sufficiently investigated. In its purest form, we believe that it is entirely soluble in boiling water, and acids seem to act on thin dried slices of it nearly as they do on cuticle.

### VII. THE ANATOMY IN GENERAL OF BONE.

156. The structure of this substance is exceedingly simple. Divide it, and examine its surfaces with a common magnifying-glass, or cut off slender films of it, and inspect them in a powerful microscope, and it will appear to be a uniform substance without fibres, plates, or cells, penetrated everywhere by delicate blood-vessels.

157. The sulphuric, nitric, muriatic, and acetic acids, when properly diluted, soften bone, and render it pliable, without its being possible to discover, by the most minute inspection, that a single particle of its substance has been removed.

158. Calcination produces just the reverse effects. If a bit of bone be placed in a charcoal fire, and the heat be gradually raised to whiteness, it will first burn with a flame, and then become quite red. If it be now removed carefully, and slowly cooled, it will be found to have been rendered as white as chalk, and exceedingly brittle. Still not a particle of the substance will appear to have been destroyed.

159. With respect to the chemical properties of this substance, we have only to remark, that we are convinced from experiment, that the *fat* which has been considered as an ingredient in bone, and which is extracted from it by boiling in water, is no part of the osseous substance, but an adventitious admixture either from adipose substance without, or from marrow within.

160. We have often endeavoured to discover sulphate of lime in the acid solution both of calcined and uncalcined bone; but always without success.

### VIII. THE ANATOMY IN GENERAL OF TENDON.

161. Bichât has described this common texture under the name of *Système Fibreux.* (*Anat. Génér.* III.) The term is objectionable, however, because it is equally applicable to nerve, muscle, or even cellular substance, as to the texture to which he has applied it.

162. Its distribution is very various, and very extensive. It forms not only those appendages to muscular fasciculi, called *tendons*, from which it has received its name, but also *ligaments, periosteum, aponeuroses, fasciæ, membranes, &c.*

163. It appears to be chiefly composed of very delicate, white, silvery-looking fibres, collected into fasciculi, which are united with each other in various ways. Sometimes they are tied together longitudinally; at other times, interwoven almost with the same regularity as the threads in a piece of cloth; and at other times intermingled in every direction.

164. The sulphuric, nitric, and muriatic acids, act upon it very nearly as they do upon cuticle. The instant it is plunged into either of them, it shrinks up, and becomes semitransparent and elastic, just as it does in boiling water, but in a much greater degree. The effects of the pure fixed alkalies upon it are singular. At first, they operate upon it somewhat like the acids just mentioned; but, instead of dissolving it after a little while, as these do, they seem to produce very little further change upon it for a considerable length of time. If, in this state, we remove it from the alkali, and pull its parts gently asunder, its delicate fibres will unfold themselves very readily, exhibiting at same time very bright prismatic colours.

### IX. THE ANATOMY IN GENERAL OF SEROUS MEMBRANE.

165. A successful injection of size or turpentine, coloured with vermilion, brings into view so many capillary blood-vessels in this membrane, that one would be almost inclined to suppose, that it was entirely composed of arteries and veins. By proper management, however, absorbents may be injected in it with quicksilver to an equal degree of minuteness. There can be no doubt, therefore, that it is chiefly composed of these two systems of vessels. Whether it contain any thing else but vessels, remains to be ascertained. Nerves have not yet been traced into it, although they may be often seen ramifying abundantly on the parts with which its external surface is connected.

### X. THE ANATOMY IN GENERAL OF SYNOVIAL MEMBRANE.

166. Bichât has enumerated a variety of circumstances, in which he conceives, that the *serous* and *synovial membrane* differ from each other. (*Anat. Génér.* IV.) It seems to us very doubtful, however, whether all these points be well founded; at all events, we do not think that any of them can with propriety be adopted as the basis of an *anatomical* distinction.

167. Synovial membrane resembles serous membrane, in so far as it is a thin substance, having one smooth free surface, turned towards certain cavities of the body, and another connected by delicate cellular substance to the sides of these cavities, or to the parts contained in them. It resembles this substance also in being transparent.

168. But it differs from serous membrane in the following circumstances:—In the first place, it is a substance possessing very little vascularity in its healthy state; none of its blood-vessels are almost ever seen filled with blood after death, nor can they be made to receive the finest injection. In the second place, its absorbents are quite incapable of demonstration. Thirdly, very delicate fibres, like those of cellular substance, or like the finest filaments of tendon, are distinctly perceptible in it after slight maceration. Fourthly, it is considerably inferior in strength to serous membrane.

## PART III.

### THE ANATOMY OF THE SKELETON.

### Article I.

### GENERAL OBSERVATIONS ON THE SKELETON.

#### I. *In the Adult Male.*

169. The skeleton of the body may be regarded as the solid frame-work which supports and contains the softer parts.

170. It is made up of 254 separate pieces of *osseous substance*, most of which contain a quantity of a matter called *marrow*, and are surrounded with a membrane denominated *periosteum*. These separate pieces, with their appendages, have the appellation of *bones* usually applied to them; and they are connected to each other in various ways.

#### 1. *Of Bones in their separate State.*

##### A. *Their Osseous Substance.*

171. In almost all bones, the osseous part presents itself under two forms. Externally it assumes the form of an uninterrupted shell or covering, which is called the *compact part*, and a very delicate texture of fine plates or fibres intersecting each other, and leaving small spaces between them, projects internally from this, which is called the *cellular* or *reticulated part*. The proportion of these two, varies in different bones.

##### B. *Of the Marrow.*

172. The chemical properties of the oily matter of the marrow, have not yet been sufficiently investigated.

##### C. *The Periosteum.*

173. This covering distinctly possesses the structure of tendinous substance.

174. We cannot regard it as correct, that it is prolonged from one bone to another over joints. In general it covers the whole outer surface of the compact substance, except at those points where one bone is united to another.

#### 2. *The Connections of Bones.*

175. The connections between bones are of two kinds; some admit of motion, others do not.

##### A. *Connections admitting Motion.*

176. It may be remarked of those bones which are united in such a manner as to enjoy motion on each other, that their touching surfaces never consist of bare osseous substance, nor even of osseous substance covered with periosteum. They are either provided with separate crusts or prolongations of cartilage, the surfaces of which play directly on each other, constituting what is denominated a *joint* or *articulation*; or they are united to one common intermediate substance, which is flexible, or admits of compression.

###### a. *Articulations or Joints.*

###### α. *The Cartilages.*

177. The surfaces of the portions of cartilage, which are in contact with each other in this mode of connection, are always as smooth as the finest polished ivory.

178. It was affirmed long ago by Dr Nesbit (*Human Osteology*), and Dr Hunter (*Phil. Trans.* 1743), and has been much insisted on of late years by Bichât (*Anat. Génér.*), that these surfaces are covered with a very delicate prolongation of synovial membrane. We are very much inclined to think, however, from a number of experiments, that these anatomists have been mistaken.

###### β. *The Ligaments.*

179. All articulated bones are partly held together by means of ligaments. These are composed of tendinous substance, and may be divided into *fascicular* and *capsular*. The *fascicular ligaments* are disposed in cords, at intervals, around the joint; the *capsular* form a continuous web, including the united surfaces in a kind of shut sac.

###### γ. *The Synovial Membrane.*

180. In all the intervals between fascicular ligaments, portions of synovial membrane may be distinctly seen filling up these intervals. They are attached to the ligaments on the one hand, and to the articulated bones on the other, just at the edge of the cartilaginous surfaces.

181. It does not seem to us, however, to have been yet satisfactorily ascertained, whether this synovial membrane be continued over the inner surface of the fascicular ligaments; or how it is disposed in joints, of which the ligaments are of the capsular kind.

###### b. *Without Articulation.*

182. The small bones of the spine called vertebræ, are united to each other chiefly in this way. The portions of them denominated their bodies, are directly connected to pieces of a flexible and compressible substance, somewhat between cartilage and tendon in its nature, one piece being common to two vertebræ.

##### B. *Connections not admitting Motion.*

183. These may be divided into two kinds, *suture* and *synchondrosis*.

###### a. *Suture.*

184. In this species, the bones are united by direct contact of their osseous substance. The contiguous parts, however, are in general more or less indented or serrated, the projecting parts of the one being fixed into holes or grooves in the other. The periosteum passes across the line of junction, and does not dip down between the united surfaces.

###### b. *Synchondrosis.*

185. In this mode, a piece of cartilage, or some

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similar substance, is interposed between the surfaces of the bones which are joined together; and their connection is further strengthened by ligaments, as in the junction of the ossa innominata with the sacrum.

3. *Dimensions and Weight of the Skeleton.*

186. The height of the skeleton of a person five feet eight inches, we believe, will be found in general to be about five feet seven inches.

187. Soemmerring (*De Corp. Hum.* Tab. I.) has made some trials of the weight of the skeleton; and, according to him, it varies from 150 to 200 ounces. But we are uncertain as to the weights he employed, and ignorant of the manner in which his estimates were made.

II. *In the Adult Female.*

188. The same general remarks which have just been made with respect to the skeleton of the adult male, apply equally to that of the adult female; only the skeleton of the latter is a little lower, and not so heavy. According to Soemmerring, it weighs in general only from 100 to 150 ounces.

III. *Before and after Maturity.*

The Osseous Substance.

189. Parts corresponding to the skeleton may be distinctly perceived in an embryo of seven or eight weeks. At this early period, however, osseous substance has not yet appeared. In the place of the future bones, we find either a pellucid substance like jelly, moulded into their general form, and surrounded with periosteum, or else a simple membrane resembling the periosteum in structure. Some bones are wholly gelatinous, others wholly membranous, and others partly in the one state and partly in the other.

190. About the end of the second month after conception, the process of ossification begins. It does not commence, however, in all parts of the skeleton at once, but takes place at different periods in different bones, or even in different parts of the same bone. Its commencement in some is delayed until a considerable time after birth.

191. When we attend to the progress of ossification in those parts of the fœtal skeleton which are at first gelatinous, we observe, that if any of these parts are converted into osseous substance so early as the second or third month after conception, they seem to undergo very little previous change of consistence. If they are not ossified, however, till the fourth or fifth month, they gradually lose their resemblance to jelly, becoming firmer, more elastic, and more opaque; and if the ossification is still further delayed, their opacity, firmness, and elasticity, rapidly increase, they acquire a pearly colour, and are converted into a substance in every respect the same as cartilage.

192. When the ossification commences in this gelatinous or cartilaginous basis, the first part which is ossified is always observed to be situated towards the centre of the jelly or cartilage; and from this point the process gradually extends in every direction. In early ossifications, the parts are so minute, that it is difficult to perceive the appearances in the gelatinous basis which immediately precede the formation of the osseous substance. But in those which commence at a later period, the parts of the cartilage which are just about to be converted into bone, uniformly exhibit a considerable degree of vascularity; and a number of little red specks are observed in them, in each of which a capillary blood-vessel seems to terminate, and in which the first bony particles that are formed generally appear.

193. When ossification commences in a membranous part of the fœtal skeleton, the osseous substance first appears in the form of a fine net-work of slender fibres, confined to a small spot in the middle of the membrane. But by the formation of additional osseous particles, this net-work is converted into a plate of bone of extreme thinness and delicacy, and having a layer of the membrane covering each surface, which may be regarded as its periosteum. Innumerable bony fibres are then observed to shoot out, in a radiated direction, from the margins of this little plate, and these are soon connected by short transverse threads of osseous substance, in such a manner, as to give the bone for a time a slightly reticular appearance. The spaces between the fibres seem entirely filled up by blood-vessels.

194. In this manner, the ossification extends through the whole membrane, splitting it, as it proceeds, into two layers, which become the periosteum of the opposite surfaces of the new bone, but remain united into one single membrane around the whole of its margin. At the same time, however, that the bone is thus enlarging in breadth, it is also increasing in solidity, from the deposition of new osseous particles between those already formed. At last, it assumes the form of a continuous plate of compact substance, the different parts of which are proportioned in their thickness to the corresponding parts of the future bone; and if the adult bone contains any reticulated substance, the cells are generally developed in the middle of this compact plate.

195. No sooner are the *cancelli* developed in any part of a young bone, than they are lined with a very vascular medullary membrane. This membrane, however, contains only a slightly viscid, reddish, and transparent fluid. It does not appear to begin to receive any admixture of oil till after birth. At first, the proportion of oily matter is small, and it increases in general so gradually, that the fluid does not acquire the consistence or composition of true medullary oil, until the period of maturity.

The Marrow.

196. In old persons, the medullary membrane seems to become less vascular, and the oil acquires a yellower colour.

197. The periosteum in the fœtus is much thicker, and more tender than in the adult. It is more vascular too, and particularly at those parts of a bone where active ossification is going on. In old persons, it is thinner and less vascular.

The Periosteum.

198. As soon as the soft rudiments of the future bones are visible in the fœtus, divisions may be observed in them corresponding to the articulations and synchondroses, but none to the sutures.

The Joints, and other Connections.

199. The ligaments and synovial membranes in the young person seem to differ in size only from those of the adult.

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200. For a considerable time after the margins of bones, that are intended to be united by suture, first come into contact, they adhere so slightly to each other, that the bones seem chiefly held together by the periosteum which passes from the one to the other. By degrees, however, as the bones are more fully developed, they are locked more firmly into each other.

201. The apparatus of the articulations seems to undergo very little change in the decline of life. But it is not unusual, in very advanced age, to find the cartilages partially converted into osseous substance. On the approach of old age too, we may almost always observe that the sutures begin to be obliterated. Particles of osseous substance are formed between the margins of the bones, the line of the suture is gradually filled up, and at last the bones are fairly continued into each other.

### Article II.

#### THE ANATOMY OF PARTICULAR PARTS OF THE SKELETON.

202. On this subject we have nothing which we think it necessary to add, at present, to what has been said in the body of the work. See *Anatomy*, from § 11. to § 72.

## PART IV.

### OF THE ANATOMY OF MUSCLES ATTACHED BY BOTH EXTREMITIES TO THE SKELETON.

203. In the article Anatomy, Part I. Chap. II. Sect. II. in the body of the work, the names and attachments of those muscles, which are connected to the skeleton by both their extremities, are given in the form of a table. No description accompanies this tabular view, of the form or structure of the muscles; but considering the length to which such a description would necessarily extend, we are rather inclined to think that the subject has been treated in that article with a sufficient degree of minuteness for a work like the present.

## PART V.

1. OF THE ANATOMY OF THE EYE, EAR, NOSE, MOUTH, PHARYNX, FASCIÆ, AND INTEGUMENTS, &c. OF THE HEAD.—2. OF THE CAVITIES OF THE THORAX AND ABDOMEN; OF THE VISCERA CONTAINED IN, AND CONNECTED WITH, THESE CAVITIES; AND OF THE FASCIÆ, INTEGUMENTS, &c. OF THE TRUNK.—3. OF THE FASCIÆ, INTEGUMENTS, &c. OF THE EXTREMITIES.

We have a few observations to offer on some of the subjects comprehended in the first and second sections of this title.

## BOOK I.

### OF THE ANATOMY OF THE EYE, EAR, NOSE, MOUTH, AND PHARYNX.

## CHAP. I.

### OF THE EYE.

204. Under the general denomination of the eye is included the *eye-ball*, the *optic nerve*, the *muscles of the eye-ball*, the *eye-lids*, the *eye-brows*, the *lachrymal gland*, and the *lachrymal passages*. We have only a few observations to offer on the eye-ball.

### *Of the Eye-ball.*

Its Dimensions.

205. The average dimensions of the eye-ball have not yet been satisfactorily ascertained.

Chemical Analysis of the Vitreous Humour.

206. By chemical analysis, Berzelius obtained from the fluid of the vitreous humour the following ingredients:

| | |
|---|---|
| Water, - - - - - | 98.40 |
| Albumen, - - - - - | 0.16 |
| Muriates and lactates, - - | 1.42 |
| Soda, with animal matter soluble only in water, - - - | 0.02 |
| | 100.00 |

The particulars of the analysis, however, are not detailed. (See *Med. Chir. Transact.* III.)

Measurements of the Lens.

207. We are not yet in possession of any measurements of the lens that are more accurate or particular than those of Petit. According to him the breadth of the lens is 4 lines, and the thickness 2 lines; the radius of the anterior surface is from 6 to 8 lines, and of the posterior from $4\frac{1}{2}$ to $5\frac{1}{2}$ lines. (*Mém. Roy. Acad. Scien.* Par. 1730.)

Morgagnian Liquor.

208. We have ascertained, by many experiments, that the *Morgagnian liquor*, which has been so often described as surrounding the substance of the lens, immediately within the capsule, does not exist in the eye immediately after death. It seems to be the product either of transudation or decomposition.

Analysis of Lens.

209. By chemical analysis, Berzelius obtained the following ingredients from the substance of the lens:

| | |
|---|---|
| Water, - - - - - | 58.0 |
| A peculiar matter, - - | 35.9 |
| Muriates, lactates, and animal matter, all soluble in alcohol, - | 02.4 |
| Animal matter soluble only in water, with some phospate, - - | 01.3 |
| Residuum of cellular membrane, | 2.4 |
| | 100.0 |

210. With respect to the peculiar matter here mentioned, Berzelius remarks, that when coagulated by boiling, the coagulum possesses all the chemical properties of the colouring matter of the blood. (*Med. Chir. Transact.* III.)

Analysis of Aqueous Humour.

211. The result of his analysis of the aqueous humour is the following:

| | |
|---|---|
| Water, - - - - - | 98.10 |
| Albumen, - - - - - | a trace |
| Muriates and lactates, - - | 1.15 |
| Soda, with mineral matter, soluble only in water, - - - | 0.75 |
| | 100.00 |

Central Hole of Retina.

212. We have been led of late, from some physiological considerations, to entertain doubts whether the little dark spot in the retina, which has usually been described under the name of the central hole, be really a hole or not. Is it certain that it is not a spot which is more transparent than the other parts; so that the dark surface of the choroid coat is better seen through it, giving it the appearance of a hole?

Composition of Black Pigment.

213. The black pigment lining the inner surface of the choroid coat and iris, is, according to Berzelius, a powder, insoluble in water and acids, but slightly soluble in alkalies. When dried and ignited, it burns as easily as a vegetable substance, and the ashes contain much iron.

Colour of the Iris.

214. The colour of the iris does not seem to depend in the least on this pigment; but entirely on the structure of its anterior surface.

Supposed Coverings of the Cornea.

215. A delicate membrane was many years ago described by Demours and Descemet, as lining the whole inner surface of the cornea, and prolonged over the anterior surface of the iris; and the merit of having discovered this membrane was the subject of very keen controversy between these two individuals. (Portal's *Hist. de l'Anat.* &c. Tom. V. p. 226.) The same description has been repeated by Bichât, in his *Anat. Descrip.* Vol. II.

216. We have many times sought for this membrane, but in vain; and are much disposed to think, that the anatomists mentioned have been deceived by certain appearances which occasionally present themselves on the inner surface of the cornea, when it has been macerated, and begins to decompose.

217. In almost all anatomical writings, the *conjunctiva* is still described as continued over the anterior surface of the cornea. It is impossible, however, to demonstrate this in the recent eye; and the substance which may be peeled off from the anterior surface of the cornea after slight maceration, is obviously a stratum of the cornea itself. This distribution, therefore, of the *conjunctiva*, which has been copied by one author from another, is a mere hypothesis; and one which, in our opinion, is not much more probable, than that the cornea is covered with a crust of bone.

## CHAP. II.

### OF THE EAR.

218. The structure of several of the soft parts of the ear seems to us to require further investigation. We have most doubts, however, as to the accuracy of the descriptions hitherto given of the contents of the labyrinth.

219. Soemmerring has, within these few years, published a very elegant and very interesting work in German, on the structure of the human ear; in which all the parts of this complicated organ are represented in engravings.

220. His description of the labyrinth corresponds pretty nearly with that which had before been given by Scarpa. We believe it, however, to be more accurate; and his representations are certainly more natural.

221. The whole inner surface of the labyrinth is said to be lined with a very delicate membrane, which sometimes exhibits an appearance of considerable vascularity, and adheres everywhere to the bone. Within this are found, in the vestibule, two membranous sacs, which do not seem to have any communication with each other; but from the larger one, which is more oblong than the other, three membranous canals extend into the three semicircular canals of the bone.

222. The membranous sacs, and the membranous canals, appear to contain a thin watery fluid; and between them and the vascular lining of the labyrinth already mentioned, a small quantity of a similar fluid seems to be interposed.

223. The portion of the auditory nerve destined for the vestibule, seems to be entirely lost on these sacs and canals.

224. We are not fully satisfied with the descriptions usually given of the aqueducts of the labyrinth. They have been too generally examined in the young subject. Are they always open in the adult; and, when open, are they distinctly lined with any periosteal covering?

## CHAP. III.

### OF THE NOSE.

225. The membrane lining those parts which contribute directly to form the cavities of the nose, possesses the same structure everywhere. Its free surface is vascular, red, and villous; the surface attached to the bones or cartilages, smooth, and silvery, like tendon. It is obviously composed of two distinct textures; but they are so closely united, that it is impossible to separate them from each other.

226. The membranes lining those cells and sinuses which communicate with the cavities of the nose, is a good deal different. It is thinner, more tender, paler, semitransparent, and promising little vascularity. Its free surface is less villous, and the surface attached to the bones does not exhibit any tendinous appearance.

227. Bichât's description of this membrane (*Anat. Descrip.* II.) is by far the best which has yet appeared.

## CHAP. IV.

### OF THE MOUTH.

228. When the jaws are closely shut, the mouth may be regarded as consisting of two regions; an *external* and an *internal*, separated from each other by the teeth and gums.

229. The *external region* is formed by the cheeks and lips without, and by the teeth and gums within. The *internal region* is bounded before, and laterally by the teeth and gums; below by the tongue; above by the hard palate; and behind by the soft palate. Between the soft palate, however, and the posterior part of the tongue, there is an opening, variable in its dimensions, according to the will of the individual, which leads into the pharynx or fauces. This is called the pharyngæal orifice of the mouth, or the isthmus of the fauces.

230. The cheeks and lips are formed of the following parts. 1. An inner membrane of a peculiar

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structure. 2. Little bodies called labial and buccal glands, situated immediately without the inner membrane; the former opposite the front teeth of both jaws; the latter opposite the grinding teeth of the upper jaw. 3. Various muscles. 4. Bodies called parotid glands, one on each side. 5. Cellular and adipose substance. 6. Skin. 7. Hairs. 8. Branches of various blood-vessels, absorbents, and nerves, supplying these parts.

231. The gums consist of a peculiar membrane attached directly to the alveolar arch of both jaws, and to the collars of the teeth.

232. The tongue is composed of the following parts. 1. A peculiar membrane continuous with the gums. 2. Under this, towards the root of the organ, lingual glands exactly like the labial glands. 3. Various muscles. 4. Two submaxillary, and two sublingual glands; one of each on each side. 5. Cellular and adipose substance. 6. Blood-vessels, absorbents, and nerves, supplying all these parts.

233. The hard palate is formed by the inferior surface of the palatine processes of the palate and upper jaw bones, lined by a membrane continuous with the gum, and similar to it in structure.

234. The soft palate is formed of a peculiar membrane, which lines both its anterior or oral, and its posterior or pharyngæal surface; of little glands, which may be called palatine, similar to the labial glands of various muscles; and of two bodies called tonsils, one on each side.

## CHAP. V.

### OF THE PHARYNX.

235. Into this cavity at the top, and on the fore part, the right and left cavities of the nose open; the two orifices being denominated the pharyngæal orifices of the nose. Immediately below, is the soft palate; and to this succeeds the pharyngæal orifice of the mouth. Below this orifice, again, is situated the opening of the glottis, with the epiglottis on its upper and fore part; and under this, there is a slight convexity, which terminates the pharynx before.

236. On each side of the pharynx, at the very top, are found the orifices of the Eustachian tubes, leading from the tympana of the ears.

237. There are no orifices on the posterior surface of the pharynx. This surface is smooth and slightly convex. A considerable portion of it may be seen through the pharyngæal orifice of the mouth, when the mouth is held wide open, opposite to a mirror.

238. The roof of the pharynx is formed by a membrane similar to that which lines the hard palate; which is attached directly to the lower surface of the basilar process of the occipital bone.

239. The posterior and lateral parts are lined with a membrane like that covering the inner orifice of the cheeks; and exterior to this is a coat of muscular fibres, belonging to three muscles called *constrictors of the pharynx*, two called *stylo-pharyngæal*, and two denominated *palato-pharyngæal*. This muscular coat is connected by means of cellular substance behind, to the bodies of the upper cervical vertebræ; the long and short recti muscles of the head, and the longi colli; and laterally, to the carotid arteries, internal jugular veins, pneumo-gastric nerves, &c.

240. The convexity under the glottis, on the fore part of the pharynx, is covered with a membrane similar to that lining the other parts, but rather paler. This is attached by means of cellular substance to the crico-arytenoid muscles of the larynx, and to the posterior margin of the thyroid cartilage on each side; and it is continuous above with the inner membrane of the glottis.

# BOOK II.

## OF SOME OF THE VISCERA CONTAINED IN THE CAVITIES OF THE THORAX AND ABDOMEN, OR CONNECTED WITH THESE CAVITIES.

## CHAP. I.

### OF THE LUNGS AND THEIR APPENDAGES.

### SECTION I.

#### *Of the Lungs.*

241. These organs may be regarded as consisting of two parts; a peculiar *substance*, and a serous membrane called *pleura*, covering the whole outer surface of this substance.

The Air-Cells.

242. The substance of the lungs is composed of a mass of cells called *air-cells*, through which certain tubes called *bronchial tubes*, together with blood-vessels, absorbents, and nerves, are found ramifying in every direction.

243. Nothing certain is known respecting the form or dimensions of the air-cells. When examined with a magnifying-glass, in their collapsed state, they appear very irregular in their shape.

244. It is still uncertain, too, whether they communicate directly with each other by lateral openings, or otherwise. Towards the surface of the lungs, they are obviously collected into a number of separate clusters, which are surrounded by common cellular substance, and have no communication with each other. For, if air be thrown into the bronchial tube supplying one of these, it will not inflate the other. Whether the arrangement be similar throughout the whole substance, we do not know.

The Bronchial Tubes.

245. The bronchial tubes ramify throughout the substance of the lungs exactly like an artery. There is no doubt that they all terminate at last in the air-cells; but they are too minute to be traced by dissection so far. We are rather inclined to think, from an examination of corroded preparations of the injected bronchial tubes, that each air-cell is supplied with a distinct branch of these vessels.

The Blood-vessels.

246. The arteries and the veins of the lungs admit of being injected to a great degree of minuteness; but no method has yet been discovered by which we can see the precise manner in which they end or begin, and the distribution of their terminations and origins, with respect to the air-cells. We learn nothing satisfactory by injecting a thin fluid, such as water, into either of these systems of vessels, and finding that it flows out by the bronchi; or by throwing it into the bronchi, and observing that it returns by the blood-vessels. Transudation admits of fluids pas-

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sing in the dead body through channels, in which they are never found to flow in the living.

SECTION II.

*Of the Appendages of the Lungs.*

247. These are the larynx, the trachea or windpipe, and the thyroid gland.

The Larynx.

248. The larynx contains two compartments, an *upper* and a *lower*, which communicate with each other by a narrow passage. The upper compartment is usually called *glottis;* and the aperture by which it communicates with the lower one, the *rima* of the *glottis.* The edges of this slit are pretty sharp; and the term *vocal cords* has frequently been applied to them. It seems to us better, however, to relinquish this appellation; since it implies an hypothesis with respect to the functions of the rima of the glottis, which, if not incorrect, is at least very doubtful.

The Trachea.

249. We have not been able to discover any structure resembling longitudinal muscular fibres in the trachea or bronchi. The whitish lines which are seen running along the back part of the windpipe when it is slit open towards its lower end, and which extend into the bronchi, depend on a peculiarity in the structure of the inner membrane. These are the lines, however, which, we suspect, have been mistaken for muscular fibres.

The Thyroid Gland.

250. It is a remark which we believe was first made by Bichât, (*Anat. Desc.* II.) that the thyroid gland, although it be supplied with large arterial trunks, is not a very vascular organ. It always contains less blood after death, than many other organs, which do not seem, proportionally, to have such large blood-vessels. We have had occasion to verify this observation very often.

## CHAP. II.

### OF THE ALIMENTARY CANAL.

251. An exceedingly interesting paper on the appearances of the stomach immediately after death, by Dr Yelloly, will be found in the *Medico-Chirurgical Transactions*, Vol. IV. The facts he has ascertained, seem to us to constitute by far the most important addition to our knowledge in this department of anatomy, which has been made for many years. We had directed our attention to this subject, for some time previous to the appearance of Dr Yelloly's valuable essay; and we have lost no opportunity since, of prosecuting the inquiry. We are happy to find, that our observations correspond almost entirely with those of Dr Yelloly.

Vascularity.

252. This very judicious and intelligent physician has found, that appearances of vascular fulness in the inner surface of the stomach, whether florid or dark-coloured, in distinct vessels, or in extravasations of various sizes, occur in every variety of degree and character, under every circumstance of previous indisposition, and in situations where the most healthy aspect of an organ might be fairly expected. They are found in every part of the stomach, but principally in the posterior part of the great end, and in the lesser curvature; and they cover spaces of various extent, but are generally well defined, and terminate abruptly.

253. These appearances preserve their distinctness for a short time only, being best marked on the first day, and soon after; but at irregular periods, becoming more obscure, the parts which were vascular, acquiring a dark red or purple tinge, which loses itself gradually. This effect more readily takes place, when the villous coat is in contact with a fluid, particularly water. They exist in the body of the villous coat, and, in general, appear to be greatest, where that membrane is the least firm and resisting. Careful dissection discovers a fine net-work of veins, between the villous and the muscular coat, from which the minute vascularity of the former evidently proceeds. The arteries are always empty, or very nearly so.

254. The vascularity now mentioned, often possesses a starred appearance, from the circumstance of its spreading in minute vessels, continually ramifying into smaller ones, so very near the extremity of the villous surface. A slight degree of friction with the point of a scalpel, will open the minute extremities of the vessels; but Dr Yelloly has never observed, that, even by squeezing the larger branches, in a retrograde way, effusion into the cavity of the stomach could be produced, so as to stain a white substance, which might be applied to the villous surface.

Thickness of the Coats.

255. Dr Yelloly has remarked, that the coats of the stomach vary very much in thickness in their different parts; the whole substance being sometimes so thin at the great end, as readily to admit of making out through it, dark figures on a light surface. This difference he conceives is produced by variations, both in its villous and muscular coats; for he found, that of two equal oval portions of the same stomach, one of which was taken at the great end, and the other near the pylorus, in the lesser curvature, the former, weighing six grains, had its villous coat, consisting of $2\frac{1}{2}$ grains, and the peritoneal and muscular together, of $3\frac{1}{2}$ grains; while the latter, weighing $19\frac{1}{2}$ grains, had its villous coat, consisting of 7 grains, and its peritoneal and muscular together, of $12\frac{1}{2}$ grains. The thickness of the peritoneal coat appeared to be pretty uniform; but that of the muscular and villous seemed to vary, not only in different stomachs, and in different parts of the same stomach, but in relative proportion in such different parts.

256. Mr John Hunter seems to have been of opinion, that the greater thinness of the stomach here described, was the consequence of an erosion of the villous coat, by the gastric juice. We think, however, that Dr Yelloly's observations clearly shew, that it is not owing to this cause. At same time, we cannot altogether agree with this ingenious author, in considering it as certain, that the difference is one which exists during life. We have often had occasion to observe, in examining the contents of the abdomen, at various periods after death, that those portions of the small or large intestines, which happened to contain air or thin fluids, or both, were considerably thinner in their coats, than portions directly continuous with them, which were empty and apparently contracted at the time of death. The thinness of the stomach at particular parts, may be owing to the same circumstance; and it is not a little in

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favour of this conjecture, that the parts of this organ which are generally observed to be thinner than the rest, are such as must be exposed, from the usual position of the subject after death, to the contact of any air or fluids, which the stomach may chance to contain at the time death takes place.

## CHAP. III.

### OF THE LIVER.

257. In the descriptions which are usually given of the internal structure of this organ, a good deal is stated as fact, which we apprehend is yet matter of conjecture.

258. Besides the absorbents, which it possesses in common with other organs, four systems of vessels are distributed through it; viz. the ramifications of the hepatic artery, the hepatic veins, the portal vein, and the biliary vessels.

259. Injection enables us to trace each of these systems to a great degree of minuteness within the substance of the liver; but, the exact termination or commencement of any of them is not known.

260. In forming our opinions, in the meanwhile, on this subject, it will be proper to keep in recollection, the direction in which the fluids have been ascertained to flow within these different vessels, in the living body. By two of these systems, viz. the hepatic artery and the portal vein, blood is constantly entering the liver; and by the other two, viz. the hepatic veins and the biliary vessels, fluids are perpetually leaving this organ. It is exceedingly improbable, therefore, that the branches of the two former should communicate with each other, or those of the two latter.

261. Whether the hepatic artery and portal vein communicate with the hepatic veins alone, or with both the hepatic veins and the biliary ducts, cannot, it seems to us, be decided by simply injecting a thin fluid like water into either of the trunks, in the dead body, and observing by what channel it escapes. For, in the first place, transudation is a source of fallacy in all experiments of this kind; and, secondly, allowing that no transudation took place, a direct communication between any two of these opposite systems of vessels, might open an indirect channel for the fluid, through the branches of the other two.

262. The portal vein has been said to resemble an artery somewhat in its structure; but we have never been able to discover any similarity between them. It has always appeared to us to have the same composition as the other veins of the body.

## CHAP. IV.

### OF THE GRAVID UTERUS.

263. The department of this subject, which seems to us most deserving of further investigation, is the structure of the Placenta.

Hunter's Description of the Placenta.

264. According to Dr Hunter's description of this substance (see *Anatomical Description of the Human Gravid Uterus.* Edit. by Dr Baillie. Lond. 1794.), it consists of two portions; a *fœtal* or *umbilical*, and a *maternal* or *uterine part.*

265. The fœtal part is composed entirely of ramifications of the umbilical arteries, and umbilical vein. These, dividing to almost infinite minuteness, extend to all parts of the placenta. The branches of the umbilical arteries finally terminate in the umbilical vein, and they have no other termination; the branches of the umbilical vein all arise from the umbilical arteries, and they have no other commencement.

266. The maternal part, consists of a whitish-coloured substance, which is spread over the outer surface of the placenta, in the form of a membrane, and sends off innumerable irregular processes, which pervade its substance, as deep as its inner surface. These are everywhere so blended and entangled with the ramifications of the umbilical system, that it is impossible to discover the nature of their union. They are interwoven in such a manner, however, as to leave innumerable small vacuities or cells between them, which have free communications with each other, through the whole mass. The maternal part is full of both large and small arteries, and veins, none of which are derived from the vessels of the fœtal part, but all from the arteries and veins of the uterus. The arteries are all much convoluted and serpentine; the larger, when injected, are almost of the size of crow-quills; and, after little or no ramification, they all terminate abruptly in the cells already described. This is their only termination. The veins have frequent anastomoses, pass in a very slanting direction, and generally appear flattened; some of them are at least as big as a goose-quill, but many of them very small; and all of them arise abruptly from the cells of the placenta. This is their only commencement.

Not satisfactory.

267. This description of Dr Hunter's, has been acquiesced in pretty generally by the anatomists of this country, and we believe also by those on the Continent. It is to be observed, however, that it is partly susceptible of demonstration, and partly hypothetical; and we confess that we do not think that the conjectural part is altogether satisfactory.

268. In the first place, the existence of cells in the placenta, we hold to be matter merely of conjecture. If melted wax, it is said, or any similar fluid, be injected into the uterine arteries, it will first fill the cells, and then return by the uterine veins; or if it be thrown in by the uterine veins, it will fill the cells and then pass on into the uterine arteries; or if an injecting pipe be simply thrust into the middle of the placenta, and melted wax injected, the whole cells will be filled, and the uterine veins also. But it does not follow from these experiments, that the cells which appear, are cells naturally existing in the mass. They may be the effect of artificial distention of its parts from extravasation of the injected fluids; and we think it favourable to this hypothesis, that, considering the size which these cells generally have in an injected placenta, there is no appearance of them, either in a collapsed state, or filled with blood, in one which is uninjected.

269. Secondly, we regard it merely as an hypothesis, that the blood-vessels of the fœtal part of the placenta do not communicate with those of the maternal part. The commencements or terminations of either system, cannot be seen; they must be deduced, either from injections in the dead body, or from observations on the state of the circu-

lation in the umbilical cord, during labour, in the living. Now, although it may be found impossible to force even a thin fluid from the umbilical arteries into any of the uterine veins, or from the uterine arteries into any of the umbilical veins, we cannot positively conclude, from this experiment, that these vessels do not communicate with each other. The same experiment often fails when tried on vessels which are known to be connected with each other. For example, there can be no doubt that the arteries and veins of the stomach communicate; yet, it is in general impossible, even with the finest fluids, to inject the one set of vessels from the other.

270. Upon the whole, therefore, we think a new series of observations on the anatomy of the placenta, very desirable. In the meanwhile, nothing seems to us to have been ascertained respecting its structure, at all inconsistent with the hypothesis, that part of the capillary branches of the uterine arteries communicate directly with corresponding branches of the umbilical vein, and part of the capillary branches of the umbilical arteries, with corresponding branches of the uterine veins.

## PART VI.

1. OF THE SITUATION AND CONNECTIONS OF THE HEART, AND THE STRUCTURE AND DISTRIBUTION OF THE TRUNKS AND PRINCIPAL BRANCHES OF THE BLOOD-VESSELS.—2. OF THE STRUCTURE AND DISTRIBUTION OF THE TRUNKS AND PRINCIPAL BRANCHES OF THE ABSORBENTS, AND OF THE GLANDS CONNECTED WITH THEM.—3. OF THE SITUATION AND CONNECTIONS OF THE BRAIN AND SPINAL CORD, AND THE STRUCTURE AND DISTRIBUTION OF NERVES COMMON TO MANY PARTS.

271. We insert this general title here, merely for the sake of pointing out the place, in which we conceive the subjects enumerated in it should be treated of, in a systematic view of Human Anatomy. The progress of the science does not suggest to us any thing of sufficient importance relative to these subjects, to demand notice in the present supplementary pages.

See, for the first division of the title, *Encycl. Britt.* ANATOMY, Part I. Chap. IV. Sect. x. and xi; for the second, Part I. Chap. III. Sect. xiv; and for the third, Part I. Chap. V.

## PART VII.

OF THE MODE OF INSPECTING THE BODY AFTER DEATH; AND OF THE PROCESS OF EMBALMING.

## BOOK I.

OF THE MODE OF INSPECTING THE BODY AFTER DEATH.

272. This process is differently conducted, according as the death of the individual has been natural, or is suspected to have been violent.

### CHAP. I.

OF THE MODE OF INSPECTING THE BODY AFTER NATURAL DEATH.

273. In this case, there is one general rule which the operator ought always to prescribe to himself; which is, that the parts to be examined should be exposed, by means of as few external incisions as possible, consistently with the speedy and complete inspection of these parts.

274. The incisions, of course, will frequently vary, according to the supposed nature of the diseased structure which is to be examined. But a few general directions may be given for conducting the process, in those cases in which inspection is most frequently required.

#### 1. *Inspection of the Cranium.*

275. Make a vertical incision from ear to ear, over the crown of the head, through the scalp; and dissect the anterior flap forwards as far as the glabella, and the posterior one backwards, to a little below the occipital protuberance. Then remove the skull-cap, by sawing through the outer table of the bones, and breaking through the inner table with a chisel and mallet. This is a more expeditious mode than sawing through the whole; and it also ensures the safety of the dura mater.

#### 2. *Inspection of the Pharynx.*

276. Make an incision through the middle of the lower lip down to the jaw-bone, and continue it through the integuments on the fore part of the neck, half way down, or altogether down to the top of the sternum. Saw through the symphysis of the lower jaw. Then detach the tongue completely from its connections with the inside of the jaw on either side, and so expose the pharynx.

#### 3. *Inspection of the Larynx and Trachea.*

277. Make an incision through the skin from the middle of the chin, straight down to the top of the sternum. Dissect off, with the flaps laterally, the parts attached to the larynx and trachea. Then cut completely through the root of the tongue, by an incision from before backwards, beginning a quarter of an inch above the os hyoides. Next revert the larynx and trachea, either by dissecting them from the œsophagus, or taking the œsophagus along with them. The glottis is thus exposed, and the rima. Both larynx and trachea may then be slit open in the middle behind.

#### 4. *Inspection of the Chest.*

278. Make an incision through the integuments, from the top of the sternum to the pit of the stomach. Dissect back with each flap all the soft parts down to the ribs. Carry the flaps backwards an inch, or an inch and a half, beyond the joining of the cartilages with the osseous substance of the ribs. Then cut through these cartilages close to this joining, beginning with the second rib, and ending with the seventh. Pull forwards the lower part of the sternum a little; introduce a scalpel behind it, and

detach the diaphragm and mediastinum from it; then saw it through, or break it, immediately below the connection of the first rib, and the cavities of the chest will be sufficiently exposed.

*5. Inspection of the Abdomen.*

279. Make one straight incision from the pit of the stomach to the pubes, through the whole parietes of the abdomen at once; and then relieve the flaps a little at top, by reverting them, and cutting off the attachments of the oblique, recti, and transversales muscles, to the sternum and cartilages of the ribs. This incision will, in most instances, suffice for an examination of all the viscera in the abdomen; and it is peculiarly well adapted for cases of dropsy of this cavity, as it retains the fluids until they can be completely and conveniently removed.

280. Where a freer opening into this cavity is thought necessary, the incision from the pit of the stomach may be made to terminate at the navel, and then one may be continued on each side from that, to the spinous process of the ilium.

281. If a still freer opening be required, the parietes may be divided by a crucial incision; one part of which extends from the præcordia to the pubes, and the other across this at right angles opposite the navel, from one loin to the other.

282. Cases sometimes occur, in which neither of these incisions admit of a sufficiently accurate inspection of the contents of the pelvis; and, in such instances, it is necessary to remove by the saw the pubal bones on each side.

## CHAP. II.

### OF THE MODE OF INSPECTING THE BODY, WHEN VIOLENT DEATH HAS BEEN SUSPECTED.

283. In these circumstances, there ought to be no restriction, either as to the time employed in the inspection, or the number or extent of the external incisions.

284. The cases of this nature usually requiring a peculiar mode of procedure, are those in which death has been suspected to have been induced, either by poison administered by the mouth or rectum; or by abortion purposely brought on.

285. When poison is suspected to have been introduced into the stomach or rectum, the whole of the alimentary canal must be removed from the œsophagus to the anus, in order that its contents may be carefully examined. For this purpose, a double ligature should, in the first place, be applied to the very commencement of the jejunum, and the intestine divided between the two threads; a similar ligature should then be applied to the ilium, close to its termination in the colon, and the tube divided in the same manner. The root of the mesentery being now cut through, the whole jejunum and ilium are removed together. A double ligature is next to be applied to the rectum, as low down as possible, and the rectum, being divided between the cords, it is to be removed, along with the whole of the colon. The œsophagus, stomach, and duodenum, are then to be extracted together; taking care, first of all, to tie a ligature round the top of the œsophagus.

286. In cases where abortion is suspected to have taken place, we hold it to be a rule which should never be deviated from, that the uterus and all its appendages should be examined *in situ*. For that purpose, therefore, the anterior parietes of the pelvis should be freely removed.

## BOOK II.

### OF THE PROCESS OF EMBALMING.

287. The object of this process is to prevent altogether, or to retard the decomposition of the body after death.

288. The following method of performing it, (which is that recommended by Dr Baillie, *Transactions of a Society*, &c. Vol. III.) with only a few alterations, appears to us the simplest and easiest.

289. In the first place, an antiseptic fluid is to be prepared of essential oil of turpentine, with a small proportion of Venice turpentine dissolved in it; and this is to be well charged with vermilion. The pipe of a syringe, such as is commonly employed in anatomical injections, is then to be introduced into the anterior femoral artery, with its point turned towards the heart; and as much of the antiseptic fluid is to be injected into the vessels of the body, as it is thought they will bear without rupture. A ligature being applied to this vessel, the pipe is then to be withdrawn, and re-introduced at the same opening, with its point downwards, so that the part of the limb below the groin may be completely injected. This done, the pipe is to be removed, the artery tied, and the skin sewed up; and the body is to be allowed to rest for an hour or two.

290. The cavities of the chest and abdomen are then to be laid open in the usual manner.

291. An aperture being made into the pericardium, this bag is to be filled all round the heart, with an antiseptic powder, composed of two parts camphor, one of resin, one of nitre, and a sprinkling of oil of rosemary or lavender.

292. Next, an opening is to be made into the trachea, just below the cricoid cartilage, and the lungs are to be injected with camphorated spirit of wine.

293. A ligature is then to be applied to the œsophagus at the cardia, and another to the rectum, as far down as possible; and the alimentary canal is to be emptied at proper points, between these ligatures, and as much of the air and feculent matter it may happen to contain, as possible. No water should be employed for the purpose of ablution. Camphorated spirits of wine are then to be injected upwards and downwards, so as moderately to distend the whole stomach and intestines.

294. The bladder is next to be slit open, at its upper extremity, and filled with the antiseptic powder.

295. The surface of all the viscera of the thorax and abdomen is then to be washed with camphorated spirit of wine, and all the intestines between them filled with the antiseptic powder; after which, these cavities are to be sewed up.

296. The mouth, nose, and pharynx, are next to be washed out with the camphorated spirit of wine, and stuffed as much as possible with the powder.

297. A sufficient quantity of the same antiseptic

powder, is then to be introduced into the passages of the external ear, rectum and vagina in the female. The humours of the eyes being let out, the powder is also to be employed to fill up the space between the eyes and eye-lids.

298. All these operations being completed, the surface of the body is to be rubbed over with some aromatic oil, such as oil of rosemary or of lavender.

299. Lastly, the body is to be inclosed in such a chest as shall completely exclude the external air. A chest of lead is best adapted for this purpose. Before introducing the body, a quantity of plaster of Paris should be spread on the bottom of the chest, for the purpose of absorbing moisture.

## II. COMPARATIVE ANATOMY.

This department of *Anatomy* has, of late years, been cultivated with so much zeal, both in this country and on the Continent, that we are persuaded nothing more is necessary to render it a very favourite branch of general study, than a more elementary arrangement of the facts which it comprehends, and a more philosophical classification of the living beings to which these facts relate.

Were all the known plants in the world submitted to the examination of a certain number of individuals, accustomed to nice and patient investigation, but altogether ignorant of the botanical arrangements hitherto proposed; and were these individuals required to classify the objects placed before them, solely according to their general external resemblance, in visible and tangible properties; we imagine there can be no doubt, that precisely the same classification would at last be adopted by them all. We apprehend, indeed, that the result of the experiment would be similar, were engravings of the plants merely, substituted for the plants themselves, provided the representations were sufficiently accurate in point of form and colouring. It is to such an arrangement as this, we conceive, that the appellation of *natural* is alone applicable.

No such classification, however, has yet been made, of the objects of the vegetable kingdom. The various *natural methods* which have hitherto been proposed, are all, in truth, more or less *artificial;* that is, founded on partial, instead of general, similitudes. This may appear, at first sight, a little extraordinary; but the causes of the defect may, we believe, be assigned with tolerable certainty.

A series of coloured representations of all the plants hitherto discovered, even if they could have been executed in the earlier periods of the art of engraving, would have constituted a work, by much too unwieldy and expensive, for the greater part of those already ardent in botanical pursuits, or who felt eager to engage in the cultivation of a science, which promises so much innocent pleasure. It became necessary, therefore, to attempt to discriminate plants from each other, by verbal description; so that botanists, in every rank of life, and in every quarter of the world, might be enabled, by the possession of a few small volumes only, to discover the name and properties of any " herb, tree, or flower," out of the multitudes which are scattered over the surface of the earth. It was in a manner, however, essential to the success of this undertaking, that the descriptive detail should be circumscribed within narrow limits; and, accordingly, it has been the constant aim of all the botanists who have successively engaged in it, to discover some circumstances of *partial* resemblance among plants, which might not only form the basis of a methodical arrangement, but admit of sufficiently concise and perspicuous description.

On these principles the Sexual System of Linnæus was constructed; and there can be little doubt, that it owes its almost universal adoption to its being founded on discriminating characters, admitting of so much shorter and more intelligible description, than those of any other method which has yet been proposed. To this system, indeed, we imagine it is generally acknowledged, the science of botany is chiefly indebted, for the rapid progress it has made in modern times. By an appeal to any of those botanical works which are composed according to the Linnæan arrangement, there is no one who, after a little practice, may not be able to discover what name any particular plant he may have gathered has received, or whether any appellation at all has yet been bestowed upon it. These dictionaries, it is true, cannot communicate to him much information respecting the external form or colour, or consistence of the plant, which he has it not in his power to ascertain, in a much more satisfactory manner, by a direct examination of the object itself; and regarding the properties of the plant, they do not, in general, profess to instruct him at all. But as the motives which prompt by far the greater number of persons to the study of botany, are, the love of discovering the names of plants from the shortest possible verbal description of them, (a pleasure nearly allied to that which results from the solution of riddles,)—or a love of displaying to others the knowledge of names thus acquired;—or a great emulation to achieve the glory of detecting a plant without a name at all;—the works we have mentioned may be truly said to serve sufficiently well the general purposes of the botanist. In doing so, too, it is equally undeniable, that they contribute materially to extend our knowledge of plants. By rendering that easy, which would otherwise have been difficult of acquisition, and by converting into a pleasure, what would else have been a toil, they add to the number of those amiable enthusiasts, who are continually employed in exploring the unknown regions of the vegetable world.

To the higher and more difficult investigations of the vegetable economist, however, neither the Linnæan System, nor any classification founded on similar principles, is at all applicable. For his purposes, a perfectly Natural Method is essentially necessary; and how much soever the botanist may feel inclined to smile at the light estimation in which we hold the difficulties of the undertaking, we confess, we cannot suppress our astonishment, that, with the aid of arts, so common and so perfect, as drawing and engraving now are, such a Method should not have been invented long before this time.

The application of these remarks to the subject of the present article, will be obvious, when we state

that not only has no Natural Arrangement of the lower animals been hitherto attempted, but no Artificial Classification of them, even, has yet been proposed, which has met with general adoption.

The imperfections and inaccuracies of the Artificial Classification of the lower animals, by Linnæus, have long been seen and acknowledged; and it is now only matter of surprise, that the same mind which constructed the Sexual System, in one division of the living world, should have proposed an arrangement so defective and incorrect in the other. This Classification, accordingly, has been supplanted in the writings of all the more eminent naturalists of late years, by that of Blumenbach, or Cuvier, or Macartney. Of these three, it has always appeared to us, that the System of Macartney is by far the most perfect, and the most likely to be generally adopted, were its merits more extensively known. It will be found under the article *Classification*, in Rees's *New Cyclopædia*. Zoologists, however, at present, are far from adhering universally, either to this Method of our countryman, or to that of either of the two great Continental anatomists, whom we have just named. Some give the preference to one, some to another, and there are not a few naturalists, we believe, who, in this unsettled state of the science, choose rather still to follow the Method of Linnæus, with all its faults, than to adopt the language of any System less generally known.

Whichever of these Classifications, however, or whatever similar Classification shall hereafter obtain the preference from the majority of naturalists; we apprehend that it can hardly be expected that zoology will derive such advantages from it, as have accrued to botany, from the facilities and precision of the Sexual System of Linnæus. It is an objection to all such zoological Classifications as we have alluded to, that they are founded too much on the internal structure of animals. Most of the discriminating characters hence derived, are, no doubt, sufficiently sure and precise; but some of them, it must be confessed, are very vague; and others are in no small degree uncertain. At all events, we imagine, the number of individuals is very few, out of the multitude of those with whom zoology is a favourite pursuit, who are either skilled enough in anatomy to look for these distinguishing circumstances, or, if they are, and feel an inclination to attempt the dissection, enjoy either the leisure or the dexterity necessary for accomplishing it. This department of natural history is, we fear, destined to make slow progress indeed, if the zoologist, before he can determine whether an animal be a Reptile or an Insect, must satisfy himself by a complete exposure of its interior frame, whether it have a brain and skeleton or no; or if, before ascertaining whether it be a Bird or a Fish, it be absolutely necessary for him to settle the nice question, whether its blood be warm or cold, or whether its heart have one ventricle or two. We will venture to affirm, that the general class to which any individual animal belongs, was never yet ascertained by any one naturalist, merely by an examination of the characters laid down for that class, in any one zoological arrangement that has ever been proposed.

Comparative Anatomy and Physiology, then, it would appear, labour at present under the same disadvantages, as that department of Vital Economy, which treats of the structure and functions of Vegetables. They have no Natural Classification to refer to; no arrangement founded on that principle, which never fails to bring together objects truly allied by nature, in all the circumstances of their economy, viz. a general resemblance in external properties, visible and tangible.

We feel confident, that, if such a method were constructed, it would not only greatly facilitate the study of Comparative Anatomy, but be the means of promoting a much more general investigation of the habits of many of the lower animals. On this account, therefore, we regret the more to learn, that, in the splendid work, which Cuvier has been employed for so many years in preparing for publication at Paris, the arrangement which this great naturalist proposes to follow, although different from that with which anatomists have long been familiar in his *Leçons d'Anatomie Comparée*, is still founded on equally artificial principles. In the article *Animal*, in the *Dictionnaire des Sciences Médicales*, he gives the following sketch of it:

"Dans un traité que nous nous proposons de publier incessament sur le règne animal, et où nous le distribuont d'apres l'ensemble de son organisation, notre première division sera en quatre grandes classes, ou phalanges; savoir: les *animaux vertébrés*, les *animaux mollusques*, les *animaux articulés*, et les *animaux étoilés;* cette division nouvelle, dont nous donerons alors les motifs avec tout le developement qu'ils comportent, nous paraît répondre au plan de la nature beaucoup mieux qu'aucune de celles qui ont été proposées jusqu'â present."

This outline of the New Classification, by the celebrated author himself, is not only sufficient, in our minds, to shew how much it is at variance with the principles of a Natural Method, but enables us also to anticipate certain objections, which cannot fail to be urged to it, considering it even as an Artificial System. We may content ourselves, at present, with remarking, that there are very few of the *animaux vertébrés*, to which the appellation of "*articules*," is not perfectly applicable; and many "*animaux articulés*," that might with as much propriety be denominated "*etoilés*," as those to which that epithet is intended to be restricted.

In the hope, therefore, that some naturalist, availing himself of the aid of engraving (for without this aid we are afraid the work can hardly be accomplished) will soon supply to zoology a perfectly Natural Method, we shall only further observe, that we should then be disposed to arrange the subjects which fall to be treated of in *Comparative Anatomy*, exactly according to the same order as we have already proposed for *Human Anatomy*.

The immense body of facts which this department of science now comprehends, renders it quite impossible to exhibit them in detail, and at same time to observe those limits which it is absolutely necessary to prescribe, even to articles of the utmost importance, in a general Dictionary like the present. A mere outline of the subject is all that can be looked for. Accordingly, in the body of the work (*Anatomy*, Part II. Chap. iv. to xii.), such an

elementary and popular view of *Comparative Anatomy* has been given, as we have no doubt will appear to our readers altogether sufficient for the purposes of the general student. The accession of facts which the science has received within these few years would fill a volume; and, as they relate chiefly to particulars, they are unsusceptible of abridgment. For this reason, nothing remains for us to do, in the present columns, but to refer those who are desirous of prosecuting the subject more minutely, to those works, general or particular, in which the more recent progress of the science has been recorded.

The most useful elementary work on Comparative Anatomy which we yet possess, is the *short system* of Professor Blumenbach. This was translated into English in 1807, in one volume octavo, with numerous additional notes, and an introductory view of the classification of animals, by one of the ablest and most intelligent of British anatomists, Mr Lawrence of London.

A series of admirable treatises on the Anatomy of the animals included in the Linnæan Classes of Mammalia, Birds, Fish, Insects, and Reptiles, will be found under these articles respectively, in *Rees's New Cyclopædia*. The four first, we believe, were written by Dr Macartney, and the last by Mr Lawrence. They contain many original observations; and are, at the same time, remarkable, not only for the extent and accuracy of the information which they display, but for the clearness of all their details.

The more important dissertations, on particular subjects relative to Comparative Anatomy, which have been composed of late years by the Continental Anatomists, are recorded in the *Mémoires de l'Institut*, the *Annales du Museum*, and the *Journal de Physique*; those by British authors, chiefly in the *Transactions* of the *Royal* and *Linnæan Societies* of London. Among these last, the contributions of Sir Everard Home are deserving of particular notice. The subjects of his investigation have been various and important; and, what is of the utmost consequence, he has accompanied almost all his descriptions with very accurate engravings. The prosecution of scientific pursuits like these, necessarily both laborious and expensive, in the midst of the toils and anxieties of extensive medical practice, evinces a degree of zeal equally rare and meritorious.

Mr Carlisle has lately read to the Royal Society of London, a very interesting memoir on the extra-vascular parts of animals. The subject is a curious one, and it has been treated in a very able manner by this ingenious author. (P.)

# INDEX.

# VEGETABLE ANATOMY.

Introductory Remarks.

In the preceding Article, the science which treats of living bodies has been denominated VITAL ECONOMY, under which is comprehended the economy of ANIMALS and VEGETABLES. Each of these departments has farther been stated to embrace two distinct objects of investigation, ANATOMY and PHYSIOLOGY. The former alone will occupy our attention in the present Article; the design of which is to exhibit a general view of the structure of plants. To the botanist, it belongs to describe their *external forms* in such manner as may serve to discriminate species, and assign to each its place in a methodical system of arrangement: It is the province of the anatomist to demonstrate, by dissection, their *internal structure*, and the construction of their several organs, so as to prepare the way for a rational explanation of their functions.

By reference to the several articles BOTANY, PLANT, PHYSIOLOGY, and VEGETABLE PHYSIOLOGY, in the body of the work, the reader will meet with many observations and descriptions which relate to the structure of plants. They occur, however, in a form so detached and scattered, are intermixed with so much extraneous matter, and, in their combined result, exhibit so imperfect an account of the subject, that we have found it necessary, in order to afford a juster view of the science in its present state, to recast the whole, and give it in a different, and we trust an improved and more systematic form. To the above mentioned articles we may occasionally refer; but, in the present, it will be our aim to collect and arrange all the more important facts that relate to the structure of plants; and these we shall submit to the reader nearly in the following order.

We shall divide the subject into two Parts; in the first of which we shall treat of the Elementary Organs, of which the Vegetable appears to be principally composed. These organs have been denominated the *vascular system* and *cellular tissue* of plants, and under these titles we shall describe, first, the nature and kinds of vessels, and then the nature and kinds of cells by which the tissue is formed. The combination of these elementary organs gives rise to certain *textures*, which are common to almost every part of the plant, and appear in the well known forms of skin, of bark, of wood, and of pith. On these we shall bestow the appellation of *common textures*, and exhibit a general view of their structure and disposition in the several parts of the vegetable body. A brief description of some minuter structures, as pores, hairs, and glands, which are also common to many parts of the plant, will conclude this division of the subject.

In the second Part, we shall enter on the consideration of the individual members and more complex organs of the plant. We shall begin with a description of the general structure of *Seeds*, and afterwards treat more particularly of those bodies under the two great divisions of *monocotyledonous*, and *dicotyledonous* seeds, tracing also the changes of form and of structure which they exhibit in their evolution and progress to the state of the mature plant. The structure of the *Mature plant* itself will next claim our attention; and we shall accordingly exhibit the anatomy of its several members, as of the *Trunk*, the *Branch*, and the *Root*, in their more remarkable varieties and forms. After this, the structure of the organs that spring from these several members, as *Buds* and *Bulbs*, *Leaves*, *Flowers*, and *Fruits*, will be separately and distinctly examined; and having thus followed the progressive changes of form and of structure exhibited in the several stages of vegetable existence, we shall terminate our descriptions by anatomical representations of the organs in which the seed was produced, and the series of appearances successively displayed in its formation.

Through the whole of the descriptive detail, we shall adhere as closely as we can to the language of demonstration; supporting and illustrating our representations of anatomical structure by continual reference to figures, selected in great part from authors of repute, and in some instances from dissections made by ourselves. We shall avoid, as much as possible, the introduction of matter of mere reasoning, or even of facts of a physiological nature (proposing to make them the subject of a future article), except in so far as they may be necessary to illustrate anatomical description, and where the better evidence of actual demonstration is not to be obtained. We are aware, that of many reputed anatomical facts very different representations have been given, all equally professing to rest on microscopical observation. In such circumstances, we can do no more than report concisely the statements of different observers; but shall dwell chiefly on those descriptions and representations which seem best entitled to credit, and appear most conformable to the analogies of other organized structures.

When we consider the immense number of species that compose the vegetable kingdom, and call to mind that in form, in size, and in structure, each species differs from every other through every period of its existence, it must appear altogether impracticable to describe and delineate any considerable number. Fortunately, however, these diversities arise not from differences in the elementary organs, but chiefly from their varied proportion, disposition, and texture. In numerous species, the disposition of the internal organs is very similar, where the external form and texture widely differ. In other instances, the arrangement and composition of the internal parts vary not less than that of the external figure. Of these varieties, we shall exhibit different examples; but a more extended and profound view of vegetable organization would, we are persuaded, diminish these apparent anomalies, and break down the limits within which some late writers have attempted to confine the forms of vegetable structure.

In describing individual parts or organs, we might have brought many concurring examples, and exhibited many similar representations, to confirm the

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views of structure under consideration; but, in general, we have dwelt only on one or two examples, and these we have selected from plants which are either important in themselves, or whose structure has been most satisfactorily displayed, or which seemed to afford the best illustration of the peculiarities we were engaged in describing. From one example clearly given, the reader will readily apprehend the nature of analogous structures, and escape the perplexity and fatigue which unnecessary repetitions might occasion.

Instead, also, of describing the Vegetable at one or two stationary points of its existence, in some of which its size is so minute as to be scarcely capable of demonstration, we have followed it through the several stages of its growth. In this way, we really study it as a living body, continually exerting its vegetative powers, and daily exhibiting the most striking variations in external form, and frequently in internal structure. We hope thus to have conferred an interest on the descriptive part, which may, in some measure, relieve the unavoidable dryness of anatomical details; to have exhibited, in some instances, clearer views of vegetable organization; and to have given a continuity to the subject which isolated dissections, at a few stated periods, could not alone have bestowed. If such displays of the growing structure be thought to partake rather of a physiological character, it may be observed, that we exhibit only the anatomical appearances, without entering at all into the nature or operation of the agents or means by which they are produced.

It remains only to add a few remarks on the nomenclature employed in the present article.

We had wished, as far as we could, to adopt that of Grew and Malpighi, the earliest, and still the best writers on this branch of science. But these eminent authors do not often employ the same terms in their descriptions; sometimes their language is vague; sometimes it rests on false analogies and hypothetical conjectures; and not unfrequently they call the same things by very different names, and use a variety of them. We have, therefore, continued only such of their terms as seemed precise and definite, and which have been sanctioned by subsequent use; but have omitted or rejected others which did not possess these recommendations.

In the description of external parts, we have adhered chiefly to the Linnæan nomenclature; but some of the terms employed by Linnæus, in relation to anatomical structure, are exceedingly vague and inappropriate; others are manifestly erroneous, and, however well suited to the purposes of botany, are not at all to be tolerated in anything that aspires to correct anatomical description.

In the anatomy of seeds, we have adopted many of the terms employed by Gærtner, in his excellent work on the *Fruits and Seeds of Plants*, most of which had previously been used by Malpighi and Grew.

Thus, in every instance, we have exercised our own judgment in the selection of terms, and, where it seemed necessary, have subjoined the synonyms of different writers. Though we presume not to say that we have uniformly chosen the best, we trust they will always clearly express the idea we designed to convey; and that, in general, they have been used in one and the same sense, and in no other. Except in one or two trivial instances, we have not ventured to introduce new terms, but have studiously sought to avoid it, retaining even an inappropriate expression, sanctioned by use, if it did not, at the same time, lead to ambiguity, or convey an idea evidently false; and we have, in general, resisted that torrent of new and barbarous terms, founded often on fancied refinements and pretended discoveries, with which several Continental writers have of late attempted to deluge this branch of science.

## PART I.

### OF THE ANATOMY IN GENERAL OF THE ELEMENTARY ORGANS AND COMMON TEXTURES OF VEGETABLES.

### CHAP. I.

#### OF THE ELEMENTARY ORGANS.

Preliminary Observations.

1. Before we proceed to describe the structure of the individual parts of vegetables, it may be useful to exhibit a general view of the elementary organs of which they seem to be composed. Such a view will prepare the reader for understanding more clearly the descriptive language hereafter to be employed, and will even much abridge the extent to which that description must otherwise be carried.

2. Every one is familiar with the natural division of plants into herbs and trees, and is aware that how different soever they may appear in form and texture, they all possess, in common, certain parts or members which we name the root, the trunk, and the branches, from which proceed the leaves, the flowers, the fruits, and seeds. Infinitely varied as these several parts are, in figure, size, and texture, they all originate from a few constituent or elementary organs, whose situation, proportions, and combination, give rise to all the diversity that we see. "Upon the anatomical analysis of all the parts of a plant," says Grew, "I have certainly found, that, in all plants, there are two, and only two, organical parts essentially distinct, viz. the pithy part, and the ligneous part." (*Anatomy of Plants*, p. 19.) "And as every part hath two, so the whole vegetable, taken together," he adds, "is a composition of two only, and no more. All properly woody parts, strings, and fibres, are one body; all simple barks, piths, parenchymas, and pulps, and, as to their substantial nature, peels and skins, are all likewise but one body; the several parts of a vegetable differing from each other only by the various proportions and mixtures, and variated pores and structure of these two bodies." (*Ibid.* p. 47.) In the anatomical descriptions of Malpighi, the compound structure is resolved, in like manner, into two constituent parts, called by him the ligneous and utricular portions.

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To these parts may be assigned the general appellations of the *Vascular System* and *Cellular Tissue* of plants, the description of which shall form the first subjects of consideration.

### Section I.

### *Of the Vascular System.*

#### Article I.

#### *General Characters of the Vessels.*

Definition.

3. By the vascular system may be understood, in a general sense, all those parts of a plant which do not exhibit the form either of membrane or of cells. It constitutes almost the entire bulk of the more solid parts of trees; and, by Grew and Malpighi, was denominated the ligneous body, in contradistinction to the cellular tissue which accompanies it, and which forms by far the largest portion of many herbaceous plants. To common observation, a piece of dry wood appears to be a mass of solid fibres, that is, a series of particles arranged in a filiform figure, and destitute of any continuous canal. Thus Tournefort and others, considered the ligneous parts of a plant to be a mass of minute solid filaments, placed parallel to each other, like the threads in a skein of silk, between the interstices of which the sap ascended; but the anatomical researches of Grew conducted him to a different conclusion. "If it be asked," says he, "what all that part of a plant, whether herb or tree, which is properly called the woody part, what all that is? I suppose that it is nothing else but a cluster of innumerable and most extraordinary small vessels or concave fibres." (*Anat. of Plants*, p. 20.) Malpighi held similar opinions concerning the vascularity of plants, which was farther attested by the microscopical observations of Hooke and Leuwenhoeck. Du Hamel, though he admits that, under maceration, the parts of plants seem capable of indefinite subdivision, yet, from many circumstances, avows his conviction of their vascularity; and Hedwig maintains that the oldest and most compact plant is but a congeries of vessels and cells, which have nothing of the character of a fibrous solid, except in the thin membranous coats by which they are formed. (*De Fibræ Vegetab. Ortu*, p. 17.)

Names of the Vessels.

4. Few circumstances have contributed more to perplex and retard our knowledge of the structure of plants, than the vague and erroneous nomenclature that has been employed to designate their constituent organs, more particularly in relation to the vascular system. Thus the several terms filaments, fibres, strings, threads, and nerves, which, in their ordinary acceptation, are understood to express a solid substance, have been constantly made use of in describing the tubes or vessels of plants. The same organs, however, even by the same writers, are frequently called tubular bodies, ligneous tubes, concave fibres, ducts, canals, arteries, veins, and vessels. In our future descriptions, we shall employ the term vessel in a generic sense, to express all the diversity of names just enumerated, and the different kinds or species of vessels we shall hereafter attempt to discriminate by appropriate appellations.

5. Vessels, as we have said, exist in almost every part of a plant. In the higher orders of animals the fluids contained in the vessels are conveyed to a central reservoir called the heart, from which they are again sent out to all parts of the body. Near to this reservoir, the vessels are few in number and large in size; and they gradually lessen in size and increase in number as they recede from it. In plants, there is no such reservoir, but the fluids which enter by innumerable mouths at the root, are at once distributed equally through all parts of the vegetable that are fitted to receive them. Hence in plants, there is little variation in the diameter of the vessels; and their general figure is therefore cylindrical.

Their Size.

6. From the extreme minuteness of the vessels, it is scarcely possible to compute their number with accuracy. By driving off their fluids without destroying their figure, as is done in the preparation of charcoal, Hooke numbered in a line, $\frac{1}{18}$th part of an inch long, not fewer than 150 vessels; therefore, in a line an inch long, there must be 2700, and in a surface of a square inch, 7,290,000 vessels, "which would seem incredible," says he, "were not every one left to believe his own eyes." These facts he verified by other observations on decayed wood, in which the vessels were empty, and also on petrifactions of ligneous bodies, in which the places of the vessels were very conspicuous. In very close and dense wood, as that of Guiacum, the vessels were still more minute than in the examples just quoted. (*Micrographia*, p. 101, 108.) In a piece of Oak of the size of about $\frac{1}{10}$th part of a square inch, Leuwenhoeck reckoned 20,000 vessels; so that in an Oak-tree of no more than one foot in circumference, or about four inches in diameter, there will be found, according to his computation, 200,000,000 of such vessels. (*Select Works, translated by Hoole*, Vol. I. p. 3.) The largest vessel observed by Hedwig (*De Vegetab. Ortu*, p. 26.) in the stem of the Gourd, appeared through his microscope about $\frac{1}{12}$th of an inch in diameter; and as his instrument magnified 290 times, the true diameter must be reckoned the 3480th part of an inch, which would give for the square inch 12,110,400 vessels. In certain plants, however, the vessels are large enough to be discerned by the naked eye, and in some cases acquire a large size.

Form Fasciculi.

7. The vessels of plants do not, like those of animals, exist single, but are collected into fasciculi or bundles, which, however, have often the appearance of single vessels. In the stems of herbs, and in roots, Grew discovered each small fasciculus to be composed of from 30 to 100, or sometimes many hundred vessels. (*Anatomy of Plants*, p. 20.) The direction of these fasciculi in the trunk is generally perpendicular, but in other parts their course is often oblique, and in their smaller ramifications they produce all sorts of figures. In herbs, the fasciculi are more or less numerous, and placed often at considerable distances from each other, exhibiting the appearance of small columns dispersed through the cellular tissue: in other instances, they are much more numerous, but destitute of any symmetrical arrangement; while, in trees, they are disposed regularly around the axis, presenting in their transverse section, the well known appearance of concentric circles in the wood.

8. In some parts, where the fasciculi stand at a distance from each other, some vessels often quit one

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Ramify.

parcel to unite with another, and return afterwards to that which they had previously left. In this manner, they are said to ramify, and frequently, by their ramification, a reticulated appearance is produced, as occurs especially in the bark and leaves. In the wood of the trunk, where they stand collaterally in a perpendicular direction, they very seldom, if ever, run into one another, but keep, says Grew, like so many several vessels, all along distinct; as, by cutting, and so following any one fasciculus, may be observed. (*Anatomy of Plants*, p. 20.) In branches and roots, though the direction of the fasciculi be changed, they seem only to break into smaller parcels, and run side by side, never inosculating with each other, nor being ramified, so as to be successively propagated one from another, as in the vessels of animals. Neither, adds he, are they wound together like threads in a rope, but are only contiguous or simply tangent, like the several cords in the braces of a drum. (*Anatomy of Plants*, p. 66.) Even in the leaf, where the vessels seem to ramify out of greater into less, as in the arteries of animals, yet, if the skin and pulp of the leaf be removed, and the vessels laid bare, it will appear that they are all of the same size everywhere in the leaf, and all continued through it, as distinct tubes, like the several threads in a skein of silk. The distribution of the vessels is not effected, therefore, by their ramifying out of greater into less, but by the division of a greater fasciculus into several smaller fasciculi, till at last they come to be single. (*Anatomy of Plants*, p. 155.)

Do not Anastomose.

9. It may be doubted whether, when the vessels of different fasciculi come into contact, they ever actually unite, and are lost in each other, forming that kind of connection which is called inosculation or anastomosis. Grew strenuously contends against any such connection of the vessels in any part of the plant. " On a superficial view, indeed, the vessels of the leaf, says he, seem to be inosculated, not only side to side, but the ends of some into the sides of others: but neither is this ever really done, the lesser fasciculi being only so far diducted as to stand at right angles with the greater; but they are never inosculated, except end to end, or mouth to mouth, after they are come at last to their final distribution." (*Anatomy of Plants*, p. 155.) Malpighi, however, from the fact of the alternate separation and conjunction of the vessels, and from analogy with what occurs in the animal system, speaks always of the anastomosis of the vessels, but he nowhere gives us anything like proof of the fact: and Du Hamel, from actual dissection of several fasciculi, regards them in their union, as resembling more the nerves than the blood-vessels of animals. When, indeed, we consider the extraordinary minuteness of the vessels, and the circumstance of their possessing nearly the same size in every part, there is no room for that continual ramification out of one into another, and consequent diminution of diameter, that occur in the vessels of animals; and the immensity of their number, together with the endless separations and reunions which their fasciculi make, seem calculated to fulfil the purposes of less general distribution in the plant, which successive division and perpetual anastomosis effect in the animal system.

7

Have no Valves.

10. Another general circumstance in the vessels of plants, is, that we do not discover in them any structure which has the true nature and use of valves, similar to what is met with in the veins and absorbent vessels of animals. Dr Hooke could never observe in their canal anything that had the appearance of valves. (*Micrographia*, p. 116.) Did such a structure exist, the absorption of nutrient matter from the lobes of the seed, and its conveyance, in a backward course, to the embryo, could not, says Grew, have place; neither could the root, as it often does, grow upward and downward both at once. (*Anatomy of Plants.*) If the piece of a root of elm-tree be cut in autumn, the juices, says Du Hamel, are found to escape indifferently at either end, as the one or the other is alternately held downward; a circumstance, he observes, inconsistent with the opinion of Mariotte, who maintained the existence of valves. (*Phys. des Arbres*, Tom. I. p. 56.). It is well known, also, that many plants may be made to grow in an inverted position, so as to put forth leaves and flowers from their roots; and large trees have been nourished by juices received through the extremities of their engrafted branches, after all connection between the earth and the roots had been cut off. In general, indeed, the extreme minuteness of the vessels seems almost to preclude the possible existence of valves in their canal: but in some instances, where the vessels in aged trees have become enlarged, membranous productions have been found to occupy their cavities, which some have alleged to perform the office of valves. They occur, however, only at an advanced period of growth, and form no necessary part of the structure of the vessel, and, instead of promoting, contribute only to obstruct the course of the fluids. It was the opinion of Malpighi that the frequent junctions which the fasciculi of vessels make with each other in their ramifications, might be considered to bestow on them a sort of valvular function: but, in most instances, these fasciculi run parallel without forming ramifications, and no such valvular function can then be considered to have place.

Thus far with regard to the general nature of the vessels of plants: let us next discriminate their several species or kinds.

ARTICLE II.

*Of the Common Sap-Vessels.*

Sap-Vessels.

11. To ascertain the nature and situation of the vessels of plants, various means have been employed. The plant has been dissected both in its dry and recent state; the natural qualities and movements of its fluids have been observed, and its vessels have been filled with coloured liquor, by causing it to vegetate in them. By the combined use of these several means, many important particulars have been ascertained; but it must be acknowledged, that the question is still beset with doubts and difficulties, and that, with relation to it, great diversity of opinion continues to prevail. A concise statement of the facts ascertained, with respect to the movements of the vegetable fluids, may perhaps serve best to define the situation and kinds of the vessels that convey them.

12. It has been proved that, early in spring

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Course of the Sap.

before the leaves appear, a watery fluid rises abundantly in the woody part of the trunk of trees, and continues visibly to ascend to the very extremity of the branches, until the leaves are developed, when, to appearance, it ceases to flow, and can no longer be collected by perforating or tapping the tree. This fluid has been shewn to ascend through the wood, and to rise, in general, most abundantly through its youngest or outmost circle: but in trees, whose vessels have not been obstructed from age or other causes, it rises through every circle to the very pith, and, as far as can be judged, in all the vessels that compose those circles. At this early period of vegetation no fluid is found in the bark; nor between it and the wood: nor in the pith: but the vessels of the bark are perfectly dry. These facts are deducible from observations on the natural flow of the fluids by Grew, Du Hamel, Walker, and others; and are supported by various experiments of M. De la Baisse, Bonnet, Reichel, and others, made by causing plants and parts of plants to grow in coloured liquors, in which the vessels of the wood alone became filled, but no tinge of colour was communicated to those of the bark. To these vessels the several names of lymphæducts, sap-vessels, ligneous tubes, ascending and adducent vessels, have been applied:—we shall in future denominate them *sap-vessels*.

Kinds of Sap-Vessels.

13. The vessels, which thus form the mass of wood, have by some writers been distributed into different kinds, and supposed to exercise very different functions. At certain periods of vegetation they appear empty; and hence Malpighi supposed two species of vessels to exist in the wood, one destined to carry sap, and the other to convey air; and to these latter, from their supposed office, he gave the name of *tracheæ*, and from their structure called spiral vessels. (*Anatom. Plantar. Idea*, p. 3.) Grew also believed these empty tubes to be air-vessels, but admitted that, at certain seasons, they carried sap. At an early period, however, Ray maintained that the vessels, thus supposed to convey air, were truly sap-vessels; and Du Hamel, in common with Grew, admitted that they carried sap in spring. Hill considered them altogether as sap-vessels, and Reichel, Hedwig, and others, by experiments with coloured fluids, proved that such was their true office. On the other hand, no experiments, says Ludwig, have yet shewn that there exist in vegetables, vessels destined to convey only air: and in this opinion, subsequent writers, with the exception of M. Kieser, have very generally acquiesced. We may therefore reject altogether the existence of air-vessels or *tracheæ* in vegetables; and consider all the vessels of the wood, by whatever name they may be called, as destined to carry sap. It will, however, be convenient to treat of their general nature and form under the distinct appellations of *sap-vessels* and *spiral vessels*, by which they are commonly known.

Opinion of Grew;

14. By Grew and Malpighi the common sap-vessels were regarded as entire tubes, having no apertures but in their direction of the length. The former represents a single vessel as having the appearance exhibited in fig. 1. Plate XV., the aperture or canal of which is not visible, unless highly magnified, as in fig. 2. According to Malpighi, these vessels send off

of Malpighi;

numerous capillary filaments to the cellular tissue, so that the cells are surrounded by a plexus of vessels, as is particularly seen in the pith of Elder and some others: and these ramifications, he adds, spring probably from the perpendicular vessels both in the bark and wood. (*Anatom. Plantar.* p. 29. Lugd. Bat. An. 1688.) These lateral ramifications were observed also by Leuwenhoeck in a piece of fir-wood, newly felled. Of this wood, he procured a longitudinal section so extremely thin, that he could see distinctly the particles of fluid moving in the vessels, as represented in the upper portion of fig. 3. Plate XV.; while lower down, on many parts of these vessels, small points or dots were visible, which he at length discovered to be round apertures: and as he did not see these apertures in any other parts than those in which he had separated the horizontal cellular tissue from the perpendicular vessels, he concluded that, at these points, these two organs were connected. He farther separated two of the vessels from the remainder, and through the microscope they appeared as in fig. 4: but the "engraver," he adds, "said that he could not possibly draw all the jagged parts that he saw, and we both of us perceived, in the broken membrane or coat of the tube, many excessively minute vessels, which, by reason of their smallness, he was unable to express in the drawing." (*Select Works of Leuwenhoeck, by Hoole*, Vol. I. p. 12.) These opinions concerning a direct communication between the vessels and cells of plants, receive countenance from the experiments of De La Baisse and Reichel with coloured liquors; both of whom observed, in some instances, a tint of colour to be communicated from the vessels to the adjacent cells.

of Leuwenhoeck;

15. It may however be said, that this communication between the vessels and cells, is maintained not by ramifications from the vessels, but through apertures or pores in their sides: and, accordingly, many appearances have been remarked as existing on the sides of the vessels, of which different authors have given very different representations, and which some have regarded as pores. Thus, on the vessels of the Fir, Malpighi observed certain dotted appearances, which he describes as roundish tubercles, and which were so numerous that they appeared to cover the vessels. On the vessels of the Elm, the Beech, and the Willow, Leuwenhoeck saw similar particles which resembled small globules. (*Select Works*, Vol. II. p. 1.) Dr Hill, one of those conceited writers who profess to study only nature herself, and affect an entire disregard of the labours of their predecessors, describes the vessels of the alburnum, or newly formed wood of the Willow, as connected with each other by a flocculent interstitial matter. When, by long maceration, this matter is detached, the vessels then exhibit a dotted appearance; and, if examined by a highly magnifying power, these dots, according to him, are so many oval swellings, and each has, as it were, a mouth. Through these mouths, which he represents as innumerable, and existing on all parts of the vessels, he conceives the fluids to be discharged into the cellular tissue (*On the Construction of Timber*, p. 18.); but he has omitted to show that the cells of the tissue possess any corresponding mouths to receive them. In fig. 5. Plate XV. is a repre-

of Hill;

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sentation of these vessels connected by flocculent matter, with their extremities collapsed from the escape of their juices, and their sides sprinkled with the little mouths which he mentions. These mouths, if they exist at all, are probably not pores in the sides of the vessels, but the little apertures seen by Leuwenhoeck, and produced by the separation of the cellular tissue, while the parts are still young and tender. The same author, speaking of the vessels of the mature wood of the Pear, states them to be close canals, as in fig. 6., with no lateral apertures in them.

of Mirbel;

16. A still later writer, following closely in the track of Hill, and who sets out with observing, that "the microscopical organization of plants is but little known, and that it is in vain to look for the true principles of the science in the works of Malpighi and Grew," declares, that not fewer than five species of vessels are to be found in the woody part of plants: These he denominates porous tubes, cleft tubes, tracheæ, mixed tubes, and vessels *en chapelet*, from their supposed resemblance to a string of beads. Of these several species, we have given representations in figures 7, 8, 9, 10, 11, and 12, Plate XV. The first species, or porous tubes, according to this writer, exist in every part of the plant, where the sap moves with freedom. Their sides are covered with small eminences or projections, in the centre of which is to be found a small pore. (*Exposition de la Théorie de l'Organisation Végétale*, p. 107.) Improving a little on Hill, he represents these pores not as promiscuously placed, but as ranged in transverse lines (fig. 7.); and through them he conceives the fluids of the plant to percolate; not however into the cells only, but out of one layer of tubes into another, in a lateral direction. In this manner, he conducts the fluids from the centre to the circumference of the wood, and at length, by a route not so easily followed, contrives to get them into the vessels of the bark, the sides of which he declares to be perfectly entire, and alike destitute of pores and clefts. (*Ibid.* p. 297.) Of such physiological notions it may truly be said, that they are every way worthy of the fantastical anatomy on which they appear to be founded.

of Bernhardi and others.

17. Several German writers have attempted to verify the observations of M. Mirbel in regard to the existence of these pores. They all differ from one another, and, as might have been expected, are all at variance with M. Mirbel. Bernhardi, following Malpighi, deems the alleged pores to be elevations on the surface of the vessels; Rudolphi represents them as vesicles attached to their sides; Link regards them as globules contained within the vessels; and Kieser, as we shall afterwards see, knows not what to make of them. These very different opinions, formed on viewing the same objects, sufficiently manifest the difficulty and uncertainty of microscopical observations made with highly magnifying powers. The causes of this uncertainty were long ago pointed out by an experienced and most sagacious observer,—the first who employed the microscope in the examination of the structure of plants. His statement may perhaps account for, though it should fail to reconcile, the differences in question. "Of such minute objects," says Dr Hooke, "there is much more difficulty to discover the true shape by an instrument than of those visible to the naked eye; the same object quite differing in one position to the light, from what it really is, and may be discovered to be, in another: and therefore I never began to make any draught, before, by many examinations in several lights, and in several positions to those lights, I had discovered the true form: For it is exceedingly difficult in some objects to distinguish between a prominency and a depression; between a shadow and a black stain, or a reflection and a whiteness in the colour. Besides, the transparency of most objects renders them yet much more difficult than if they were opaque. The eyes of a fly, in one kind of light, appear almost like a lattice drilled through with abundance of small holes; in the sunshine they look like a surface covered with golden nails; in another posture, like a surface covered with pyramids; in another, with cones; and in other postures of quite other shapes." (*Micrographia*, Preface.)

### Article III.

#### *Of the Spiral Vessels.*

Description.

18. Various as have been the opinions of writers respecting the *common* sap-vessels of plants, they have differed yet more in their views concerning the position, number, size, structure, and uses of those which have been denominated *spiral*. The common fathers of Vegetable Anatomy, Grew and Malpighi, who, at the same time, but in different countries, prosecuted their inquiries, for many years, without any knowledge of or communication with each other, are nearly of one opinion on all the more important points in relation to these vessels. Later writers have differed alike from them, and from each other, on almost every point. As the subject is of fundamental importance in the economy of vegetables, we shall endeavour, at the risk even of a little extension of our plan, to set before the reader the leading facts and opinions concerning it; to canvass their relative merits; and deduce from the whole such conclusions as seem most nearly to approach the truth.

Opinion of Malpighi;

19. Malpighi describes spiral vessels as existing in the ligneous parts of all plants. He called them *spiral tubes*, because, when extended, they were resolved, not into separate rings, but into a single zone, which might be drawn out to a great length. In general, they form continuous tubes, but are sometimes contracted at regular distances, so as to resemble somewhat a series of oblong cells. One of these contracted spiral vessels is represented in fig. 14. Plate XV. at the extremity of which, the spiral filament is in part drawn out, and similar appearances of the spiral structure are exhibited in figures 9. and 10. by Mirbel. In herbs, according to Malpighi, these spiral vessels constantly accompany the common sap-vessels, and are ensheathed by them; in shrubs, they occur in every part of the wood, single or in clusters; and in trees, an intermixture of spiral vessels with the common sap-vessels, is observed in every part of the wood. In the Fir, they are found immediately beneath the bark, and are so numerous as to constitute the chief bulk of the wood. They exist with the sap-vessels in the petioles and ribs of the leaf, and likewise in the petals of the flower. In

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the roots, they are also met with, and in some roots are so abundant, as to exceed in bulk all the other parts. They exist, he adds, in every part of the plant except the bark; and are annually formed with the alburnous vessels of trees. (*Anatom. Plantar. passim.*)

of Grew;

20. From the writings of Grew we collect also, that spiral vessels exist in every part of a plant, except the bark. In the root they are numerous, of very various size, and their bore is generally larger than that of the common sap-vessels. In the trunks, both of herbs and trees, they are equally visible; and in position, size, and number, subject to great variation. Sometimes they are collected into fasciculi; at other times they are disposed in rays; and in other instances they are arranged in a circular form: They stand sometimes next to the pith, in other instances next to the bark; and in other cases again, they alternate with the common sap-vessels in every part of the wood. They have a more ample bore than the common vessels, and vary in size to at least twenty different degrees. In the leaf, they always accompany the sap-vessels; and both in its petiole and ribs, are constantly surrounded or ensheathed by them. They have a similar position in the petals of the flower, and in the vascular parts of the fruit. (*Anatomy of Plants, passim.*) Hence, then, it appears, from the dissections of Malpighi and Grew, that, in every plant in which vessels are to be seen, and almost in every part of it, spiral vessels abound; they exist, however, only in the *ligneous portion*, or that part in which the sap *ascends*, and are never to be found in the bark.

of Du Hamel;

21. By Du Hamel, the spiral vessels, supposed to convey air, are described as existing in the leaves and the flowers, the petals of which are almost wholly composed of them. In the herbaceous portion of young branches, they are also well seen; which portion afterwards becomes ligneous; so that it cannot be doubted that they exist in the wood, though he could never discover them but in young branches. (*Phys. des Arbres*, Tom. I. p. 42.) If, however, all the empty vessels, seen in a transverse section of the wood, be deemed air-vessels, and all air-vessels have a spiral structure, then, says this author, they would, in many plants, form a great part of the ligneous body. From these large vessels, however, he has seen, in autumn, fluids to escape; so that they are not properly air-vessels, or, as Grew observed, they sometimes carry sap. They are not to be found in the bark.

of Hill;

22. Under the common name of sap-vessels, Hill delineates all the varieties of vessels that constitute the wood; they are largest in the outer circles, smaller in the others; they contain, says he, in spring and at midsummer, a limpid liquor; but at all other seasons they appear empty, and have therefore been erroneously deemed air-vessels. He says nothing of their spiral construction; but describes the vessels, which form the chief mass of the wood, as possessing solid and firm coats, forming an arrangement of plain and simple tubes; as in fig. 6. Plate XV.; resembling those of the alburnum, except that they have no mouths in their sides. (*On the Construction of Timber*, p. 8. & 19.) But though, with Du Hamel, he was unable to trace their spiral structure in the wood, yet there can be no doubt of their existence in that part; which, as we shall afterwards show, has been recently demonstrated by Kieser.

of Reichel;

23. M. Reichel maintains their existence in all parts of the plant. By causing plants to vegetate in coloured fluids, he traced them from the roots, through the trunk and branches, to the extremity of the leaves, and into all parts of the flower,—as the calyx, the petals, the style, the stamina, and the anthers. In fruits and in seeds, and in the radicle and plume of the latter, they were equally apparent. The coloured liquors, as they rose, communicated a tinge to the cellular tissue of the wood, as was previously observed by De la Baisse; but no trace of colour was ever observed either in the bark or pith, which therefore contains no spiral vessels. He considered the spiral vessels as the organs everywhere conveying nutrient matter to the plant, and as having no title to the appellation of air-vessels. (*Encyclop. Méthodique*, Article *Physiol. Végét.* p. 288.) Similar experiments of Hedwig and others, confirm these facts as to the universal distribution of the spiral vessels, and their bearing to every part the fluids absorbed by the roots. In his late work, M. Kieser, as we shall afterwards see, in describing the vascular system of the ligneous parts of plants, regards it as composed entirely of spiral vessels, and asserts their existence in every part of the plant except the bark and pith.

of Kieser;

of Mirbel

24. Against these combined authorities M. Mirbel opposes his fanciful views. We have already enumerated the five different species of vessels which he regards as constituting the woody part of plants. According to him, true spiral vessels (which he continues to denominate *tracheæ*) are not to be found in the root, but only in the trunk and the parts which are produced from it. Even in the trunk, they are to be found only around the pith, and never in the exterior ligneous layers. He admits that they exist in all soft and succulent parts, and that coloured fluids rise in them as well as in the other varieties of vessels; but they never are to be found either in the bark or pith. (*Exposition de la Théorie de l'Organisation Végétale*, p. 74, 78.) It appears, therefore, that the vessels which are thus erroneously called *tracheæ*, are destined to carry fluids; and as to the parts in which they do or do not occur, the opinion of M. Mirbel weighs as nothing with us, in opposition to the facts observed by so many preceding and subsequent writers.

Spiral Vessels convey Sap.

25. From the combined observations, therefore, of all the preceding writers, with the exception of M. Mirbel, we collect that the vessels heretofore called air-vessels and *tracheæ*, and which possess a spiral conformation, exist together with those called common sap-vessels, in every part and organ of the plant, except the bark. It appears also, that, though they are often found empty, yet their true office is to carry sap. This may be concluded not only from the actual occurrence of sap in them early in spring and again in autumn, and from the entrance of coloured fluids at all seasons; but from the circumstance that, in some parts, no other vessels appear to exist by

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which the rising sap can be conveyed. Are we, therefore, with many, to consider them, from the period of their formation, as a species distinct from the common sap-vessels, or are both to be held merely as varieties of one common kind?

Period of their Formation;

26. It is allowed, on all hands, that spiral vessels are most readily visible, and are most numerous in the tender and succulent parts of vegetables, in which they form almost the entire bulk of the vascular portion. In the alburnous part of trees, which is added annually to the pre-existing wood, they are not so readily seen. Even in trees, however, while still succulent, the first circle of vessels formed, contains spiral vessels; as Du Hamel observes, and even Mirbel admits; but, at a later period of vegetable growth, the whole of the vessels, formed annually in trees, are represented by Grew as common vessels, which, he adds, "begin to be formed in spring; but the spiral vessels not till the latter end of summer, or thereabouts, at least not till about that time do they appear." (*Anatomy of Plants*, p. 131.) Malpighi also describes these spiral vessels as gradually appearing in the alburnum, and continually augmenting in size in every successive ring of wood. A similar remark, as to increase of size, is made by Grew: "the spiral vessels," says he, "being amplified in each annual ring, at least for a certain number of years, so as to form a vessel of a wider bore:" (*Anatomy of Plants*, p. 130.) and accordingly, in all the plates of both these writers, and in those of other authors, the spiral vessels are always represented of different sizes in every part of the wood.

27. From the foregoing facts, it would seem, that, in the young and succulent parts of plants, the spiral construction of the vessels is almost, if not actually, coëval with their existence; but that, in more rigid textures, they are not so early formed, or at least are not discoverable in parts in which they are subsequently seen. Hence, therefore, we must suppose a sort of *transformation* to occur with respect to these vessels, or, to use the language of Grew, that they "are post-nate, and seem produced by some alteration in the quality, position, and texture of their fibres." If, indeed, spiral vessels exist in every part of the wood, but are not for some time visible in the alburnum, and if the alburnum be, as it most certainly is, the substance by which the ligneous layers are successively formed, then it follows, that the occurrence of spirals in the wood must be the result of some change induced on the vessels that at first constituted the alburnum. Hedwig, indeed, considered all the alburnous vessels to possess from the first a spiral conformation, and that they gradually acquired the characters they possess in the wood. We shall presently see that the researches of Kieser support the same view, and thus go to establish the doctrine of transformation, first announced by Grew. Mirbel, however, protests against the transformation of one variety of vessel into another, and maintains that each of the five species, which he enumerates, retains, without change, its original character and form. He nevertheless describes his fourth species, or what he calls mixed tubes, (fig. 10.) as composed of the three preceding species; and "such," he adds, "is the simplicity of vegetable organization, that frequently one and the same tube exhibits (as in fig. 12.) all the several species combined." (*Exposit. de la Théorie*, &c. p. 78, 80.) That the same vessel, from the operation of local causes, should sometimes exhibit, in different parts, a variety of appearance and form, is perfectly consistent with the principle of change and transformation which has been supposed to have place; but that nature should from the first combine in one vessel, unsusceptible of future change, five different species of forms, is not quite so credible; and to ordinary minds would certainly afford no proof of the "simplicity" of her operations.

their Transformation;

are a variety of Sap-Vessels.

28. If then we adopt the opinion, that in young and succulent parts the vessels which carry sap have from the first a spiral construction; and if, as seems to be proved by the dissections of Grew, of Hedwig, and of Kieser, no other vessels, destined to such an office are, frequently, to be found, then we must conclude that, in such parts, only one species of sap-vessels exists, to which, from the first, the spiral construction belongs. If, on the other hand, it appear that, in the more rigid texture of the alburnum of trees, no spiral vessels are at first to be found, but that they afterwards become visible in the wood, then it follows, from what has been already stated, that the spiral vessels of the wood are produced from the common sap-vessels of the alburnum, and are consequently to be regarded, not as an original species, but only as a variety of one common kind. That such probably is the fact, will farther appear from the account afterwards to be given of the structure of these vessels, and of the actual transformations which they seem to undergo. Even those who may still be of opinion, that a difference in *external form* warrants a nominal distinction of species, must, we think, admit that, in *office*, no ground for such distinction exists; but that all the vessels in the ligneous parts of plants are destined to exercise one and the same function. In relation to the economy of vegetables, this is a fact of far greater importance than any opinions that may be formed regarding the varieties of appearance or structure in the vessels themselves.

### Article IV.

*Of the Structure of the Sap and Spiral Vessels.*

Structure of Sap-Vessels.

29. We have next to offer a few remarks on the structure of the vessels we have been engaged in describing. On this head, we shall not go much into detail. When we have seen such difficulties attending the correct observation of them in their entire forms, it may fairly be presumed that still greater perplexity must accompany the investigation of their constituent parts. What, therefore, we have to advance, may be regarded rather as matter of opinion than of fact; and, in the present state of the science, this point must be deemed more a subject of curiosity than of use.

Opinion of Malpighi;

30. According to Malpighi, the common sap-vessels of the wood, when viewed longitudinally, appear to be formed of a series of small vesicles or cells mutually opening into each other. These cells possess different forms, but in some vessels there seems to be no trace of such a cellular structure. In the

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Oak, the cells are represented to possess a roundish figure, and in the Vine they possess an oblong form; as in Plate XV. fig. 13. (*Anat. Plantar. Idea*, p. 2—24.) In these, and similar instances, Malpighi seems either to have mistaken a series of elongated cells for vessels, or to have conceived that the contractions, occasionally formed in the vessels of certain plants, afforded evidence of their being constructed originally from cells. It is certain that, in the vessels of most parts of plants, no such cellular construction is apparent.

of Grew;

31. Grew, on the other hand, considered the common sap-vessels to be composed of strait fibres, or rather smaller vessels, placed parallel to each other, and set round so as to form a cylindrical tube. (*Anatomy of Plants*, p. 112.) In the opinion of Leuwenhoeck the vessels are composed of two fine transparent coats, formed of other vessels exceedingly minute, which are disposed partly in a longitudinal, and partly in a circular direction. (*Select Works*, by Hoole, Vol. I. p. 11.) Du Hamel attempted to gain a knowledge of their structure, by submitting them to long maceration. By this method, he separated the ligneous layers into leaflets thinner than the finest paper, and the fasciculi of fibres or vessels that composed these layers, were farther separated into minuter filaments, placed parallel to one another, like the threads in a skein; and these filaments again seemed capable of almost indefinite subdivision. (*Phys. des Arbres*, Tom. I. p. 31.) Hill considered the vessels of the alburnum to be formed of the same matter as the cells. He describes them as at first very delicate, and to collapse when emptied of their fluids. Sometimes the coat of which they were formed resembled a thin parchment, in which traces of lines surrounding one another were visible, so that the coat seemed as if composed of several membranes that were vascular. In one instance, where a strong light was made to penetrate the vessel, it appeared as if composed of numerous cells; but, on farther examination, these seeming divisions altered their places, and were found to proceed from small portions of watery sap still retained in the vessel. This appearance, as he properly observes, may be a very necessary lesson against hasty judgments. (*Construction of Timber*, p. 33.)

of Leuwenhoeck; of Du Hamel; of Hill;

of Mirbel.

32. M. Mirbel's opinion concerning the formation of vessels may next be shortly noticed. He sets out with asserting, that "the entire mass of the plant is nothing but cellular tissue, the cells of which differ only in form and dimensions." This he declares to be the basis of his theory; and he may perhaps be right in thinking, that "no one, before himself, had formed a similar conception of vegetable organization." The cells and vessels of this tissue are farther considered to be produced out of one and the same *membranous tissue*. In forming cells, this membrane is supposed to dilate in every direction; in producing vessels, it increases only in length. (*Exposit. de la Théorie de l'Organisat. Vég*. p. 9—103.) Of the structure of this primitive membrane itself, he professes to give no information; and his account of the manner in which the vessels are produced out of it, is so entirely mechanical, so clumsily conceived, and so incapable of execution, that we deem it altogether unworthy of the attention of any one accustomed to contemplate the structure and formation of organized textures.

Structure of Spiral Vessels. Opinion of Malpighi;

33. Concerning the structure of the *spiral* vessels, opinions have varied still more than in relation to those just considered. Malpighi describes them as composed of a thin zone, formed of a pellucid silvery plate, somewhat broad, which, being placed spirally, and united at its edges, constructs a tube, interiorly and exteriorly, somewhat rough. When this tube is drawn out, it does not separate into distinct rings, but is resolved into a continuous spiral zone. At particular places, these vessels are sometimes contracted, so as to exhibit the appearance of oblong cells opening into each other, as in fig. 14 Pl. XV. In size they greatly surpass the ordinary sap-vessels; and their canal is then frequently occupied by membranous vesicles, which nearly fill their cavity. (*Anat. Plantar*. p. 3—26.) These vesicles were also observed by Leuwenhoeck, and their appearance, both in the transverse and longitudinal section of an enlarged vessel, are represented in fig. 15.

of Grew;

34. According to Grew, the thin plate that forms the spiral vessel, is not always of the same breadth, and, instead of being flat, it has sometimes the form of a round thread. When minutely examined, the spiral zone, he adds, is never one single piece, but consists of two or more round filaments placed collaterally, but perfectly distinct. These component filaments he regards as united by other smaller transverse filaments, and the thin plates which they form by their connection, constitute the spiral vessel;—"as if we should imagine," he adds, "a piece of fine narrow ribband to be wound spirally, and edge to edge, round a stick, and the stick being drawn out, the ribband to be left in the figure of a tube, answerable to a spiral vessel." As, however, the ribband is composed of numerous threads, placed parallel to each other, so is the plate that forms the spiral vessel; and it is according to the greater or less delicacy of the vessel examined, and the manner of its dissection, that it appears to be constituted either of a flat plate, or a round filament. The spiration of the filaments he considered to be made in the root, from right to left, and in the trunk, from left to right. (*Anat. of Plants*, p. 73, and 117.)

of Du Hamel; of Hedwig;

35. The opinion of Du Hamel, with respect to the construction of these vessels, was very similar to that of Grew, and he employed the same analogy of a ribband twisted round a stick, to illustrate it. Hedwig gave a very different account of them. He considered the spiral vessel to be composed of two distinct parts; one a membranous canal conveying air, and the other a spiral tube rolled round it, by which the fluids were conveyed. The spires of the tube, in some instances, are represented as close; in others, they are separated, and the intervening portions of the membranous canal exhibit a dotted appearance. He considered all the sap-vessels, from their first formation, to possess this compound structure, and, by a series of changes, which he professes to describe, to be ultimately transformed into the solid fibre of the wood. (*De Fibræ Vegetab. Ortu*, p. 25.) Others, also, have believed the spiral vessel to be formed of a membranous tube, but have denied that it

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conveyed air, and the spiral tube of Hedwig they have regarded as a solid plate or filament. From the different appearances which they exhibit, M. Treviranus and Bernhardi distinguish several varieties of spiral vessels, as does also M. Kieser, whose account of these vessels is not only the latest and most elaborate, but that probably which approaches nearest to truth. We shall, therefore, subjoin a brief abstract of his observations on the situation and structure of these vessels, and more particularly on the series of *transformations* which they seem to undergo.

of Kieser.

36. According to M. Kieser (*Mém. sur l'Organisation des Plantes*, p. 115, à Harlem, 1814), spiral vessels are found in all the more perfect plants, from the earliest period of their existence, and in all parts of them except the bark and pith. In herbs, they are collected into fasciculi of thirty or more vessels; in trees they constitute the wood, and are annually augmented in number by a new layer. In different plants, and even in different parts of the same plant, they vary much in size, being generally largest in succulent plants, especially those of rapid growth; and in such plants, they continually augment in size. In some woods, they are extremely small; in others, much larger. In aged plants, both in the root and trunk, they are at length more or less completely obstructed by a species of membranous vesicles, previously observed by Malpighi and Leuwenhoeck, which originate from the sides of the vessels. Nothing but air is commonly found in their cavity; but in the wood of Guiacum, he has seen all the spiral vessels entirely filled with resinous matter, and the whole cellular tissue completely filled with the same matter. He does not know what anatomical relation subsists between the spiral vessels and the other organs; but thinks there is no direct communication between them and the cells.

37. The construction of these vessels M. Kieser professes to have studied with the greatest care, and to have established incontestably the following points. Sometimes, says he, only one fibre, sometimes many, go to form the spire of a vessel. These fibres are commonly round, sometimes a little flattened, and are twisted spirally about an empty space, so as to form a tube. The spiral fibres in young plants, and sometimes in mature ones, are in close contact; in other instances they are separated, and the interstices are then occupied by a dotted or punctuated membrane, as is very frequent in trees; or sometimes they are connected by ramifications which proceed from the spiral fibres themselves. From the minuteness of the spiral fibre, it is difficult to decide whether it is a solid or tubular body, and often, from the same cause, to pronounce whether it is round or flattened. It is transparent; has considerable consistence and tenacity; and, in some plants, appears to possess elasticity.

38. The number of fibres that form the spire of a vessel is very various; sometimes, as before remarked, there is only one, but more often several, which are twisted in the same plane, and the same direction. He has seen nine fibres thus united, and when unrolled, the spires of the vessel then seem to form a kind of ribband. When many fibres are employed to form a spire, they always run parallel, and do not cross; so that the side of the vessel has never more than the thickness of a single fibre. At their first formation, the fibres are not united; it is only in more advanced age that they become united, either by ramifications from their edges, or by a peculiar membrane. The direction of the fibre, in twisting, is sometimes from right to left, and sometimes the contrary. The size also is very various. In young plants it is very small, so that a millimetre comprises the diameter of 2600 of these fibres; and, in some instances, they have little more than half that size. In older vessels they have a larger size. Between the knots of the trunk, they are simple, and do not ramify, but in the knots they undergo great changes of form, and are variously ramified and combined.



### Article V.

*Of the Transformations of the Spiral Vessels.*

Varieties of Spiral Vessels.

39. M. Kieser proceeds next to treat of the transformations or metamorphoses of the *simple spiral vessel* into several varieties; to which, from their peculiarities of construction, he assigns the names of the *annular*, the *punctuated*, the *ramified* and *reticulated* spiral vessels, and another variety he calls vessels *en chapelet*. In essential character and function, however, all these varieties are said to agree; the only difference is, that of external form. Of each of these varieties, we shall subjoin a short description.

Simple Spiral.

40. The first variety, or rather species of vessel, out of which the others are produced, he calls the *simple spiral*. It is constructed of one or more fibres, twisted spirally, and placed contiguous to each other, so as to form a round cavity within. In general, the spires of the fibre are in contact, but sometimes there is a space between them. See *a*, fig. 51. Plate XV. In the latter case, the side of the vessel is closed by the walls of the adjacent cells, but never by any new production of membrane, either without or within the vessel itself. These simple spiral vessels are found in every young plant, and in the newly formed parts of old ones, and give origin to the other varieties. Their size is smaller than that of others; in some instances they have not more than one-eighth or one-tenth of the diameter of other varieties. They are the only variety found in some of the inferior tribes of vegetables. The number of fibres in each spire varies from one to nine.

Annular Spiral.

41. Another form of these vessels is that of the *annular spiral*. In this variety, the component fibre has the form of numerous rings, disposed in a perpendicular line between the ranges of cells; fig. 51. *b*. These rings are very analogous to the spires of the preceding variety, are of the same size, and are often combined with them in the same vessel. They occur in a great many plants, and, in herbaceous plants, occupy the same position as the simple spiral vessels, that is, next to the pith. The rings of which they are constructed are sometimes separated from each other only by a space equal to their own diameter; but, in other instances, they are separated to eight or ten times that distance, forming then the substratum of the third variety, or punctuated spiral vessel.

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Punctuated Spiral.

42. From the two simple varieties of form just described, other more complicated forms are produced as the plant advances in age. Thus, the third variety, called the *punctuated spiral vessel*, is constructed by one or more round or flattened spiral fibres; the spires or rings of which, not being connected, leave between them interstices more or less large; which interstices are filled with a membrane more or less thick and transparent, and variously dotted or punctuated, from which circumstance the name is derived.

This structure is imperfectly represented in fig. 51. *c*, and much more clearly by the letter *d* of the same figure, in which the white lines indicate the spiral rings, and the intervening dotted substance represents the punctuated membrane; at the top, a portion of the anterior side of the vessel has been removed, so as to display its inner and posterior surface. In this variety, the rings are never contiguous. Such vessels occur only in the more advanced age of herbaceous plants, but seem to be original formations in the alburnum of trees. Their size is frequently eight or ten times greater than that of the two former varieties, especially in the stem; but they are much smaller in the root. They always occupy the most exterior part of the vascular fasciculus of herbs, while the two preceding varieties are found next to the pith. In trees, on the contrary, the largest vessels of the annual layers occupy the place nearest to the pith; and all the spiral vessels in these layers belong to this punctuated variety, except those immediately next to the pith. The spiral fibre of these vessels is of very various size. In the largest vessels of this class, its size is greatest; in other instances, it is so small as to be scarcely visible. It is often difficult to determine whether its form is spiral or annular; in herbs, it appears to be spiral; in trees, annular.

43. The membrane which fills the interstices of the spires and rings, and connects them together, is not visible in young vessels; but is produced in more mature age, as is proved by the fact that this membrane is often common to two contiguous vessels, and connects respectively their rings together. Hence it is, that the membrane never surrounds the spires, nor is it surrounded by them, but only occupies the interstices between them; and, from the same cause, the spires themselves are always prominent on the surface of the membrane. In this variety of vessel, the spires cannot be unrolled without tearing their connecting membrane. This membrane, at an early period, is transparent, but becomes opaque from age.

44. As to the points or dots on this membrane, they have by some been taken for pores on the surface; by others for clefts produced by the junction of the spires. M. Kieser confesses that he has not yet been able to satisfy himself on this subject. They are clearly not clefts, and it is against the supposition of their being pores, that their position has always a relation to the spires, and not to the adjacent cells. In the wood of Sassafras, however, these points seemed pierced by a hole exceedingly small; but, in other instances, they appear quite dark, and similar to those which are found on the vesicles that fill the cavity of aged vessels, and where there is not the smallest reason for considering them as pores. He thinks there is a great analogy between the formation of these vesicular membranes within the vessels, and that membrane by which the spires are connected in this variety of vessel. In some plants, the size of these dots is large, and they appear transparent at the centre; in other instances, they are extremely small. Their form is oblong or elliptical, and they are always ranged in a determined line, parallel, in general, to the direction of the spires.

Ramified Spiral.

45. The fourth variety of spiral vessel is said to have the same origin as the last, being formed in part by the spires or rings of the two first varieties; but the interstices between these are filled, not by membrane, but by small ramifications, produced from the rings themselves; and these ramifications are often so implicated as to form a net-work; whence the names of *ramified and reticulated spiral vessels*. Like the former variety, they do not exist in the young plant, but are the consequence of the gradual changes of advanced age, and produced by a similar series of actions. They are formed of one or more spiral fibres, the spires of which are contiguous in the young plant, but separate at a later period; and the interstices are filled up by new ramifications from the spiral fibre itself. In the first period of their formation, when there are but few ramifications, he names them *ramified* spirals; and when these become more numerous and implicated, *reticulated* spirals. They are found but in few plants, and those of the more succulent kind; they do not attain the size of the preceding variety; are associated in the same plant with the simple and annular spirals; and in the fasciculi, occupy the same place as the punctuated spirals, that is, next to the bark. They are more transparent than the punctuated spirals, and occur more frequently in the root than the stem. In the representations given of these vessels by M. Kieser, they appear to differ from the preceding variety, chiefly in the position of the spiral rings, which are more or less obliquely situated, and sometimes send off a sort of branch, as is represented near the bottom of the vessel *d* in fig. 51.

Vessels en Chapelet.

46. The last variety, or vessels *en chapelet*, discovered and named by M. Mirbel, are found only in those parts where the perpendicular growth is obstructed, and the vessels, taking a horizontal direction, suffer a complete change of character. It is therefore in the knots of the trunk, in the tubercles of roots, and in similar parts, that such vessels occur. They take their origin occasionally from all the other varieties, and are, in truth, nothing but these varieties changed by the qualities of the knot. They are formed by contractions occurring at short distances, which diminish the diameter of the vessel, and dispose it into the form of irregular oblong cells or utricles threaded on one another, as in fig. 51. *e*; or as in fig. 11. copied from Mirbel, with which the representations of Kieser nearly coincide; but he makes the figure of the utricles much less regular. The vessel itself also has a tortuous course in the knot, and sometimes many are ramified and combined, so as to form a kind of reticulated appearance. This, however, is effected by vessels leaving one fasci-

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culus and passing to another, and does not seem to be a true ramification of one vessel out of another. The construction of the sides of this variety of vessels is the same as that from which they take their origin. Thus, if they are formed from simple spiral vessels, their sides have the simple spiral form; if from punctuated spirals, then the vessels *en chapelet* possess the punctuated membrane, and so with respect to the ramified variety of vessels. The contractions in these vessels are not produced by any displacement of the spiral fibres of the other varieties; but their true cause is to be sought in the function of the part, and the action of the knot itself. Every spiral vessel, whether simple, punctuated, or reticulated, may thus be metamorphosed in the knots, into a vessel *en chapelet*, and again lose this character, and resume its original form in the internodial spaces.

47. Such is the account given of the construction and metamorphoses of the spiral vessels by M. Kieser. It is, in every part, amply illustrated by figures, made from dissections of various plants. These drawings everywhere support the descriptive detail; and if the microscopical observations from which they are made be correct, no doubt can exist of the truth of the doctrine. That considerable changes do occur in the vessels of plants, after their formation, seems most certain; and the series of appearances exhibited by M. Kieser, presents, as we think, nothing inconsistent with probability, nor beyond the powers of vegetable organization. Neither do they militate against the previous descriptions of Malpighi, Grew, and Hedwig; but, on the contrary, receive, generally, confirmation from them. M. Kieser, however, has pushed his inquiries much farther, and given to the doctrine of transformation a more precise and systematic form. He has not ventured to speculate on the probable causes of these curious changes; but were this the proper place for such discussion, and were the facts, connected with the functions of these vessels, fairly before us, in addition to those which regard their structure, we think that an explanation, tolerably satisfactory, might be obtained. But the prosecution of this subject we must defer to a future occasion.

Uses of the Spiral Vessels.

48. We collect, then, from the whole of the foregoing statements, that all that part of plants, which is commonly stiled the *ligneous portion*, is composed chiefly of vessels, which, however different in size and external figure, are destined to one and the same office, that of conveying *sap;* and that these sap-vessels extend from the extremities of the roots to the points of the leaves, and exist in all the organized productions of plants.

This, however, is not the conclusion at which M. Kieser arrived. Though he has demonstrated that the great mass of the ligneous part of plants consists of spiral vessels, and admits that they receive and convey coloured fluids, yet, from the circumstance of their appearing sometimes empty, he regards them, with Malpighi, as tubes destined to convey only air; and supposes the sap of plants to be carried, not by what are called the vessels, but by certain little canals, of doubtful existence, hereafter to be described, and which have been named *intercellular canals.* (*Mém. sur l'Organisat. des Plantes*, p. 87, 199.) That, however, he should, at the same time, admit the capacity of the spiral vessels to receive coloured fluids, and reject the belief that fluids, destitute of colour, are received by them, is not a little singular; for the colouring particles in the liquor must, and do oppose obstacles to its reception, which fluids of a more simple nature do not experience; and when once such liquors gain admission, they leave behind them traces of their course, which a colourless fluid does not. M. Kieser has altogether overlooked the facts observed by Grew and Du Hamel, of the actual existence of sap in these vessels, both in spring and in autumn; and he seems to be entirely unacquainted with the influence which the developement of the leaves, as we shall presently show, exerts on the movements of the vegetable fluids.

49. But it has been the fate of these vessels to experience the utmost licence of opinion in regard both to their structure and functions; nor does it seem probable, that these opinions will soon settle into anything like uniformity. While some have supposed the vegetable to be composed almost entirely of spiral vessels, others limit their presence to a few parts only; and others again altogether deny their existence. Some will have them to be solid fibres; others make them sap-vessels, or nutrient vessels; and others again suppose them to convey only air. Hedwig believed them to convey at the same time both nutrient matter and air; and Bonnet was of opinion that they were entitled to be considered not only as the lungs of the plant, but a sort of muscles also, by which many of its parts executed different movements. (*Recherches sur les Feuilles*, p. 138.) A late writer, however, and a Professor, it seems, of medicine in the university of Jena, M. Oken, is of opinion, that they ought not to be deemed either simple fibres, or vessels, or lungs, or muscles; but that they execute a function for the plant analogous to that of the *nerves* of animals; and ought therefore to be named the vegetable nerves. (*Kieser's Mém. sur l'Organisat. des Plantes*, p. 174.) The bare enunciation of such opinions must, we think, be sufficient to ensure their rejection.

Termination of the Vessels.

50. Rejecting these fanciful and extravagant notions, and adhering to the opinion that the spiral vessels are a variety only of the common sap-vessels of the plant, we shall conclude this branch of the subject with a brief notice of their common modes of *termination.* If we begin at the root, we may consider these vessels as terminating at that part, by continuation of canal, in the capillary *absorbents of the rootlet.* As, farther, the vessels of plants, like those of animals, are the only organs which convey the materials out of which, not only the fluid, but the solid parts of the plant are formed; it may, in a general sense, be said, that their modes of termination are as numerous as the kinds of distinct parts or organs which the vegetable system contains. Hence, therefore, as the cellular tissue of plants contains various matters often precisely similar to those which exist in the vessels, it may be inferred, that the vessels have a termination in those organs; and this inference may perhaps carry more weight with many than the attempts before related, of Malpighi and Leuwenhoeck, to demonstrate it

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anatomically. Another termination of these vessels must be in certain minute and ill-defined organs called *glands*, which separate from the mass of fluids peculiar secretions; and a fourth mode may, in the leaves, be in other vessels, which carry back the juices from those organs. The last and fifth mode of termination is into transpiring or exhalent organs, by which a certain portion of the contents of the vessels is discharged: So that in plants, the sap-vessels terminate externally at one extremity in absorbents, by which fluids are received; and at the other in exhalents, by which these fluids are discharged.

### Article VI.

#### *Of the Proper Vessels.*

51. By observation of the natural flow of the sap, combined with the results of experiments made with coloured liquors, we have endeavoured to determine the situation and kinds of vessels by which it is conveyed. The same method will best assist us in ascertaining the nature and place of those which have been called *Proper Vessels.* Of these also, many species have been described by authors, the existence and characters of which we shall afterwards attempt to ascertain.

Course of the Sap,

52. It was before stated, that, early in spring, the sap of plants rises through the wood alone, and that no fluid whatever is then to be found in the bark. At a later period, however, the case is completely reversed; for the vessels of the wood no longer appear to carry sap, and those of the bark then become abundantly supplied with it. This difference is very clearly and concisely stated by Grew. "The sap," says he, "in many plants, as the Vine, ascends visibly through the wood for a month, in March and April, and rises through every ring of wood to the very centre, yet, at the same time, there ariseth no sap at all out of the bark, nor between it and the wood." "But late in spring," he continues, "and in summer, the sap is no longer visible in the wood, but is abundant in the bark, in the inner margin adjacent to the wood." Du Hamel too remarks, that when the lymph rises abundantly through the wood in spring, the bark is dry, and adheres to the wood, and no sap then issues from it, nor from between it and the wood; but, later in the season, he adds, the bark yields abundance of sap. These statements have been verified by the multiplied observations of various subsequent authors.

modified by the developement of the Leaves;

53. But why is the sap thus present only in the wood at its first rising in spring? Why at a later period does it cease to be visible in that part? And how and why does it afterwards find a passage into the bark? Some observations of Du Hamel, Hales, and Walker, point, we think, to the true cause. In spring, says Du Hamel, when the sap rises vigorously, the buds have not appeared; when they begin to open, the sap then flows less freely; and when the leaves are fully developed, then the flow of sap entirely ceases. Dr Hales also remarks, that, towards the end of April, when the young shoots come forth, and the surface of the Vine is greatly increased by the expansion of the leaves, the sap then ceases to flow in a visible manner till the return of the next spring. All bleeding trees, he adds, cease to bleed, as soon as the young leaves begin to expand enough to perspire plentifully, and draw off the redundant sap. The bark of Oak, too, separates easily when lubricated with sap; but before the leaves appear and perspire, the bark will no longer run (as they term it), but adheres most firmly to the wood. (*Vegetable Statics*, 3d edit. p. 126.) In like manner, in an experiment of Dr Walker, a Birch-tree bled from every perforation in its trunk, and from every cut extremity of its branches, until vernation or budding began; then the bleeding was almost immediately checked, and when the young leaves had pushed beyond the *hybernaculum*, the bleeding entirely ceased. (*Edin. Phil. Trans.* Vol. I. p. 31.)

It is however certain, that though the sap was no longer visible in the wood after the leaves were developed, it continued nevertheless to rise through it; for in no other way could the leaves obtain the large portion of fluid which it is known that they constantly discharge by transpiration; and coloured fluids manifest their presence in the vessels of the wood, as well after as before the developement of those organs. The leaves, therefore, must be regarded as the organs which, by their perspiration, draw off, as Dr Hales observes, the redundant sap; and hence in an experiment, where a notch was cut two or three feet above the lower end of a stem, though a great quantity of sap passed by the notch, yet was it perfectly dry; because, says he, "the attraction of the perspiring leaves was greater than the force of trusion from the column of water." (*Veg. Statics*, p. 111.)

passes through the Leaves to the Bark.

54. Not only, however, does the developement of the leaves render the sap no longer visible in the wood, but they also appear to be the organs by or through which it finds its way to the bark. In all the experiments just recited, the bark continued dry until the sap disappeared from the wood; in other words, until it was drawn off by the leaves; and then, and not till then, the bark became moist, and continued laden with sap through the rest of the summer. Now, as it has been before shewn that no sap enters the bark by the roots, nor gets into it directly from the wood, there is no other known channel by which it can be conveyed, except through the leaves; and these, therefore, necessarily appear to be the organs by which it is apparently carried off from the wood, and by or through which it, at the same time, finds its way to the bark.

This inference appears to follow, not only from the fact of the bark continuing dry until the leaves are developed, but from the circumstance that it is again rendered dry, after having become moist, if these same leaves be removed. If, says Du Hamel, we remove the leaves of a young tree, when in full sap, and whose bark is easily detached, in a few days after the same bark will adhere as closely to the wood as it commonly does during winter. This direct connection between the leaves and bark, is also well illustrated in an experiment of Hales, employed by him for a very different purpose. From two thriving shoots of a Pear-tree, he cut, in several places, half an inch of the bark off all round. All the ringlets of bark between these incisions had a leaf-bud upon them except one, and all but this

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one ringlet grew and swelled at their bottoms till August; and the larger and more thriving the leaf-bud was, so much the more did the adjoining bark swell. (*Veg. Statics*, p. 149.) Mr Knight also found the bark of the Vine to become shrivelled and dry when the leaves were stripped off; but in those parts in which it communicated directly with the leaves, it continued moist and flourishing. (*Phil. Trans.* 1801, p. 335.)

55. By connecting, therefore, the circumstances attending the flow of sap with the developement of the leaves, we gain satisfactory reasons for all the apparent anomalies observed to attend its course. In spring, before the appearance of the leaves, no natural outlet for the escape of the rising sap exists, and therefore, when the vessels are cut or perforated, they readily pour out their sap, or bleed; but late in spring, and in summer, when the leaves are developed, the more watery parts of the sap are thrown off by transpiration; and, while this process proceeds, the fluids do not then accumulate in such quantity in the minute vessels of the trunk, as to be effused, or bleed through their cut or perforated sides. A cold day, however, or a moist and still atmosphere, by checking transpiration from the leaves, restores more or less the propensity to bleeding from the trunk; and in autumn, when fructification begins, and vegetation makes a pause, the same disposition to bleeding recurs in the trunk, from the check imposed on the more active powers of growth.

Qualities of Sap in the Bark,

56. It is farther evident, that, when the vessels of the bark become supplied with fluid, they could not have derived it immediately from those of the wood, since, in these different parts, the fluids have frequently no sort of agreement in properties. Thus, Grew remarks, that almost all plants, late in spring and in summer, bleed from their bark; and the sap has either a sour, sweet, hot, bitter, or other taste. At this period, the bark of the Vine yields a sour sap; but, "what is vulgarly called bleeding in the Vine, is," he adds, "quite another thing, both as to the liquor which issueth, and the place whence it issues—that is—it is neither a sweet nor a sour, but a tasteless sap, issuing, not from any vessels in the bark, but from the air-vessels of the wood." (*Anatomy of Plants*, p. 125.) Malpighi also was well aware of the difference in the qualities of the sap, and thought every plant possessed its peculiar sap; but he has not so accurately defined the situation of the vessels that contain it. Du Hamel, however, points out distinctly the difference of quality in the sap of the bark and wood. In the bark of some plants it is white; in others red; and in others yellow: It is in some instances milky; in others resinous; and in others gummy. In many plants it has a sweet taste; in some it is caustic; and in others insipid. It has sometimes much odour as well as flavour, and frequently it is destitute of both. (*Phys. des Arbres*, Tom. I. p. 68.)

acquired in the Leaves.

57. But, if the qualities of the sap in the bark be thus different from those of the sap in the wood; if these peculiar qualities are detected in it, only after the developement of the leaves, and the leaves be the organs by which alone the sap can be conveyed from the one part to the other—then it seems to follow, that the sap must acquire these new properties in the leaves, during its transmission through them. Malpighi remarked the existence of this altered sap in the leaves, and held them to be the organs which prepared nutrient matter for the plant; and Dr Darwin, by immersing plants of Spurge in coloured liquors, not only saw, as others had previously done, the red fluid ascend through the leaf; but another fluid, of a white colour, returning, at the same time, from the extremities of the leaf, and descending into the petiole. (*Botanic Garden*, Vol. I. Notes, p. 450—453.) This same returning fluid, Mr Knight observed, in similar experiments, on branches of the Apple and Horse-Chesnut trees, and even traced it through the petiole into the inner bark, by the vessels of which, it seemed to be conveyed to the extremities of the roots. (*Phil. Trans.* 1801.) The motion, therefore, of the sap in the bark, is not that of *ascent*, as Grew and Malpighi and many others have believed; but of *descent*, as the observations and experiments of De la Baisse, Du Hamel, Knight, and others, abundantly prove. To these vessels of the bark, Grew assigned particular names, according to the apparent quality of the fluid they conveyed. Malpighi gave them the general appellation of *vasa peculiaria*, from their containing a fluid different from the common sap. By others they have been called *cortical vessels*, a term, however, not applicable to many tribes of vegetables which are entirely destitute of bark. Lastly, Du Hamel and others denominated them *proper vessels*, which term differs but slightly from the appellation of Malpighi, and, though not very precise, is that we shall continue to employ.*

58. From regarding the newly formed vessels of

* The view thus presented of the course of the sap, and the modifications which its movements and qualities experience from the developement of the leaves, may assist in the determination of the important and long-agitated question regarding the proper period of *felling* timber, as it relates both to the bark and wood. The most proper period for the timber, is doubtless that in which it is most dry or destitute of sap; and the properest period for the bark, both as regards its chemical condition, and the facility of stripping it, is, when it is most succulent, and filled with its "proper juices." But these respective periods and conditions do not happen to coincide, and therefore, the time at which the wood is in best condition, is that in which the bark is in its worst; and *vice versa*. If, therefore, the qualities of the bark dictate the period of felling, it will be late in spring or in autumn, when it is most abundantly filled with its proper juices, and of course, when the wood also is necessarily filled with fluid, and in an active state of vegetation; if, on the other hand, the condition of the wood regulate the period, then it will be late in winter, or before the sap rises in spring, when the wood is destitute of sap, and the bark, of course, is necessarily dry and adherent. To reconcile these opposing conditions, it seems desirable, as far as it may be practicable, to strip the

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Description of the Proper Vessels;

the wood as part of the bark, Grew uniformly represents the bark as possessing two distinct species of vessels, in which he has been since followed by several other writers; but the vessels which he calls *lymphæducts*, belong rather to the wood, so that we may regard him as describing only one species of *proper vessels*. In herbs, these vessels stand sometimes in distinct parcels or columns; sometimes they are disposed in a ring; sometimes they have a radiated position; and sometimes they are more intermixed with the sap-vessels, and seem to alternate with them. In trees, the vessels of the bark are more distinct, and have a much more regular appearance. They are commonly postured near the inner margin of the bark, and, when viewed in a longitudinal direction, seem collected into fasciculi which are more or less numerous, and the component vessels of which continually diverge and join with others, so as to form a reticulated appearance; as in fig. 18. Plate XV. Of these reticulated fasciculi, many layers exist in an old tree; and to these layers the thickness of the bark is chiefly owing. As they proceed inward, the direction of the fasciculi is less oblique, so that near to the wood they are almost straight: Hence, the spaces formed by the reticulations are very unequal, often large in the exterior part of the bark, and diminishing in size towards the wood; they are everywhere filled with cellular tissue. Such is a general description of the *proper vessels* of the bark as given by Grew, Malpighi, and Du Hamel. The organs here described, we regard as truly vessels; but some writers have also described, as vessels, various collections of the proper juices which occur in different parts of the cellular tissue of the bark, and have thus lost sight altogether of the anatomical characters which distinguish vessels from cells.

their Structure;

59. The vessels which thus form the vascular portion of the bark appear to differ but little in structure from the more simple vessels of the wood. Grew considered them to possess a similar structure, from believing them to be formed by the inner bark, at the same time with the vessels of the wood; and, therefore, he adds, "they may be reasonably thought similar in the bark and wood." (*Anat. of Plants*, p. 112.) Malpighi regarded them as simple tubes, containing sometimes peculiar juices, but advances nothing particular respecting their structure. (*Anat. Plantar.* p. 3.) M. Mirbel's opinion deserves some notice, inasmuch as he declares the structure of these vessels to differ entirely from all those of the wood. Their sides, says he, are perfectly entire; they have neither pores nor clefts, and may therefore be deemed simple tubes. (*Exposit. de la Théorie de l'Organisat. Végét.* p. 109). A single vessel of this kind is represented in Plate XV. fig. 16.; and in fig. 17. a fasciculus of the same vessels magnified, is given, as delineated by M. Mirbel. A remark also of Hill, if it be deemed to rest on correct observation, is entitled to great attention. "The vessels of the bark that form the fasciculi are not," says he, "united to each other, but are connected with the cellular tissue at numerous places, and, when separated from it, there appear on the sides of the vessels small oval depressions, dotted as it were with pinholes." (*On the Construction of Timber*, p. 28.) These appearances he regards as of a glandular nature, but their description corresponds better with that of Leuwenhoeck respecting the lateral ramifications from the vessels of the wood; and they may probably be the points at which communication is effected betwixt the vessels and cells.

their Reticulation;

60. The cause of the reticulated appearance which the vessels of the bark exhibit in trees, is doubtless to be attributed, as we think Du Hamel somewhere remarks, to their peculiar mode of growth. A new layer of cortical vessels is every year added to the inner surface of the bark, as well as a new layer of ligneous vessels to the outer surface of the wood; so that, as Grew observes, the new matter of the tree is every year distributed two contrary ways; one part falling outward towards the bark, and the other part retaining its situation inward to constitute the wood. At first, the newly formed cortical vessels are straight, and stand parallel, like those of the wood; but, by the continual growth of the new parts, formed between the bark and the wood, the older vessels of the bark are gradually forced outward, and being thus every year disposed around a larger cylinder, are necessarily more and more separated from each other, and produce at length that net-like form which we observe them to possess. The newly formed vessels of the wood, on the other hand, retain their original position, and, therefore, preserve their parallelium, seldom or never exhibiting those flexures and reticulations so common to the vessels of the bark.

their Size;

61. In the bark, as well as in the wood, the vessels are found to possess different sizes. In the Pine, vessels containing turpentine are represented by Grew, which are very much larger than the common sap-vessels, and are surrounded by smaller ones, exactly as the large spiral tubes of the wood are said to be ensheathed by the common sap-vessels. The milky juice of a species of Sumach is contained in very large vessels, disposed so as to form a ring, and each large vessel is surrounded by many smaller ones. (*Anat. of Plants*, Tab. 20.) The appearance of these large vessels in one species of Pine, is well represented by Hill, and the account he gives of their formation is probably correct. In this tree (*Pinus orientalis*), some of these vessels form oval openings, large enough to admit a straw; these openings occupy the centre of the bark, and are surrounded by a ring of smaller vessels; as their contents are soluble in alcohol, it is easy to obtain them empty. In fig. 19. Plate XV. the vessels of this tree, as they appear in the bark, are displayed; the woody portion of the tree has been scooped away, so that the longitudinal aspect, as well as the transverse sections of them, is exhibited. From a strict inquiry into

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tree of its bark while standing, in autumn, at or a little before the period of fructification, when the bark must possess its richest qualities, and be in the best condition to separate; and to fell the tree late in winter, when the wood is destitute of sap, and its vegetative powers are most completely suspended.

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their nature, Dr Hill concluded that these larger vessels were originally the same as those of the smaller fasciculi in the bark of the same tree; "so that, if we conceive one of these smaller fasciculi opened in its centre, and the vessels driven every way outward, till they are stopped by the substance of the bark, we shall have an idea of the structure of this large vessel, which is nothing more than a great cylindrical hollow formed in the centre of such a fasciculus." (*Hill on the Construction of Timber*, p. 29.) It is in trees that have copious and viscid juices, that these enlarged vessels are formed; and where the juices do not concrete, it is probable, that, as the vessels annually recede from the centre, they suffer a reduction in size, from the continued effects of desiccation and compression to which they are exposed.

their Position.

62. The foregoing varieties appear alone entitled to the appellation of the *proper vessels* of the bark. In many tribes of vegetables, however, as will afterwards be shown, no distinction of bark and wood exists; but one uniform distribution of vessels extends from the centre to the circumference of the plant. Such plants have also their *proper vessels*, but the place and disposition of these vessels are not so precisely ascertained. From the mode in which their growth is accomplished, as well as from observation of their structure, it may be inferred, that their *proper vessels* are distributed through the whole substance of the plant, accompanying, in every part, the sap-vessels. In some plants, possessing this arrangement of parts, such as different species of wheat, Malpighi describes and delineates a *vas proprium* as forming a part of each fasciculus of vessels; and a similar intermixture of the two kinds must, we conceive, exist in all similar structures.

63. Even in many plants, possessing a distinct bark, vessels containing proper juices are found in the wood. In every circle of wood, from the inmost that surrounds the pith, to the outmost in contact with the bark, vessels containing a gum, turpentine, or some other concrete or coloured juice, may frequently be found. Malpighi conceived them to exist in all plants, though, from the nature of their fluids, they could not always be distinguished; and he believed them to afford a highly perfect juice for the nutrition of the plant. According to Grew, "the turpentine vessels that are scattered up and down the wood of the Pine and Fir are the self same which did once appertain to the bark; but being pinched up by the wood, they are become much smaller pipes." (*Anat. of Plants*, p. 115.) Du Hamel also regarded them as similar to those of the bark, but rendered much smaller by compression. In the Pine and Fir, they are disposed circularly around the axis, much like the sap-vessels, and alternate with them. (*Phys. des Arbres*, Tom. I. p. 41.)

In *Piscidia erythrina*, the proper juices are of a scarlet colour, and the vessels that contain them are therefore readily discerned wherever they exist. This plant has been selected by Hill to demonstrate the position of these vessels. In the bark, they are collected into fasciculi, all the vessels of which contain coloured juices, and are disposed in a ring on the inner margin of the bark. Within this ring stands the alburnum, through the substance of which many smaller red vessels are distributed, and similar red vessels are more sparingly seen in every layer of wood, particularly in that which envelopes the pith. (*Constr. of Timber.*)

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64. Now, the red vessels thus observed in the wood of the above mentioned plant, must either have been formed in the situations they occupy, or transported from some other place. The latter supposition is inadmissible, inasmuch as the wood of trees is formed by layers of new vessels superimposed on one another; and no removal of the old vessels, nor reproduction of new vessels within the old layers, ever takes place; consequently, no actual transposition of vessels could occur; nor could new vessels be developed in the wood after it had been completely formed. If, however, an alternate deposition and absorption of matter go on into, and from the cells, it is possible that the vessels might, in this way, become filled with a matter different from that which they originally possessed; but in the case before us, a readier explanation presents itself. The new matter of the wood is formed at the same time, and in the same place, as that of the bark; and through this new woody matter the red vessels were dispersed as well as in the bark. Consequently, every addition made to the ligneous layers would furnish some vessels that contained these proper juices; and this being annually repeated, would exhibit that intermixture of proper vessels with sap-vessels, which is observed in all the ligneous layers of this and many other trees. Hence these *proper vessels* of the wood must be held to retain the position in which they were originally produced; and cannot be said to have approached nearer to the centre, but only, by the addition of new layers exterior to them, to be placed farther from the circumference of the tree. As Grew, therefore, held the alburnum to be a part of the bark, he might correctly say that these vessels "did once appertain to it."

### Article VII.

*Of Collections of the Proper Juices in the Cellular Tissue.*

In single Cells.

65. Beside this accumulation of the proper juices in certain vessels of the wood, it frequently happens that depositions of similar matter occur in all parts of the cellular tissue of plants. In the bark of the Oak and Poplar, and of other trees, resinous concretions are often found in the cells; they are situated irregularly, and, according to Malpighi, are observed even in very young bark. Sometimes the cells containing milky and resinous juices are so postured in the bark, says Grew, as to form cylindrical channels, which are neither parallel nor anywhere inosculated, but run, with some little obliquities, distinct from one another. They appear to be formed out of the cells, and are not bounded by any walls or sides proper to themselves, but only by those of the cells. (*Anat. of Plants*, p. 112.) They are often short and tortuous, always isolated, and are sometimes placed irregularly; at others, disposed in a circular form. They occur sometimes in the pith, and possess very different sizes and figures. They have fre-

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quently been deemed a species of *proper vessels*, from the mere circumstance of their containing similar juices, and from possessing sometimes an elongated form; but they are organs which, neither in form nor in function, bear any resemblance to vessels. Mirbel proposes to name them *secretory canals*, and M. Link *cellular reservoirs*; the term certainly most generally applicable, and involving no hypothesis respecting either their formation or functions.

In Cellular Reservoirs.

66. The manner in which these cellular reservoirs may be produced in the bark or pith, is readily explained, on the supposition that a communication everywhere subsists between vessels and the cells. One set of vessels has been shown to receive and carry out sap to the leaves, and another to bring it back from them to the bark; and these latter vessels are everywhere, in their course, surrounded by cellular tissue. Hence the cells, in every part, may receive a portion of the fluid which the vessels are employed to convey. Thus in herbs, the cells both of the bark and pith are filled with fluid, which led Grew to believe that the sap was actually transmitted through those organs; but at the same time he delivers facts which, even in his own opinion, prove that it is derived directly from the vessels. Not only in herbs, but "in every annual growth, whether of a sprout from a seed, of a sucker from a root, or of a scyon from a branch, the pith is always found the first year full of sap; but in the second year, the same individual pith always becomes dry, and so it continues ever after. One cause whereof is, that the lymphæducts of the bark being, the first year, adjacent to the pith, they do all that time transfuse part of their sap into it, and so keep it always succulent. But the same lymphæducts, the following year, are turned into wood, and the vessels which are then generated and carry the sap, stand beyond them in the bark; so that the sap, being now more remote from the pith, and intercepted by the new wood, cannot be transfused with that sufficient force and plenty as before, into the pith; which, therefore, from the first year, always continues dry." (*Anat. of Plants*, p. 124.)

All that is here said respecting the transfusion of the common sap from the vessels to the cells, as it ascends through the wood, is equally applicable to the *proper juices* as they descend through the bark. During the first year of growth, both the sap and proper vessels are adjacent to the pith, as well as to the bark, and each order may therefore transfuse its fluids into the cells of either. The common sap, from retaining its fluidity, is frequently removed by absorption, and the cells that contained it appear empty and dry; but where the proper juices are transfused, and become viscid or concrete, they are retained, and appear in different quantities and forms both in the bark and pith, according to the nature and properties of the juices from which they are derived, and the texture and situation of the tissue into which they are poured.

In Intercellular Canals.

67. To these collections of the *proper juices* in the cells of the cellular tissue may be referred the opinions of those who describe them as existing sometimes in vacuities betwixt the cells. M. Treviranus professes to have discovered certain interstices between the cells, formed in a mode hereafter to be explained, to which he has given the name of *intercellular canals*. According to him, these canals contain the proper juices, and convey them to all the cellular parts of plants; and are the true *proper vessels* of the bark. We before saw that M. Kieser, after making the wood to consist almost entirely of spiral vessels, and then converting these vessels into tubes destined only to convey air, supposed the sap to be carried by these same intercellular canals. (*Kieser's Mém. sur l'Organisat. des Plantes*, p. 36.) With M. Treviranus he also considers them as the real *proper vessels* of the bark, by which alone the juices are conveyed to all parts of the cellular tissue. (*Ibid.* p. 216.) If such canals really exist betwixt the cells, it is probable, that, like the cells themselves, they may sometimes become reservoirs of the *proper juices*; but simply on that account, to pronounce them vessels, is, in an anatomical sense, exceedingly incorrect; and to make them afterwards supersede the existence of the real vessels themselves, seems nothing less than downright extravagance and absurdity. Were there any truth in such statements, we might at once banish from the organization of plants all the varieties of vessels, whose situation, structure, and characters we have been labouring to describe and define. But the opinions of these writers have not at all shaken our faith in the facts observed by their predecessors; and as long as the vegetable functions shall continue to be exercised as they have hithero been, so long, we believe, will a vascular system, such nearly as we have attempted to demonstrate, be employed as the chief instrument in their execution.

## Section II.

### *Of the Absorbent and Exhalent Systems.*

#### Article I.

#### *Of the Absorbent System.*

68. Connected with the vessels that distribute the fluids through organized bodies, is another system of vessels by which extraneous matter is taken up to support the growth of parts, and supply the waste occasioned by the exercise of the various functions. To these vessels Anatomists have given the name of *Absorbents*. The function which they perform is carried on either from the external surface, or from some internal part of the body: and its exercise, in animal bodies, may be distinguished into three kinds or stages. The first is that in which new or extraneous matter is taken up and added to the system, as in the absorption of substances from the skin, or of chyle from the intestines: the second is that in which substances previously separated from the fluids by secretion, but without becoming organized, are again taken up by the absorbents, and reconveyed into the blood-vessels, as in the absorption of milk, bile, and fat: the third kind is that in which the secreting organs themselves, and successively all the solid parts of the body, are removed by the action of the absorbent vessels. By plants, this function is exercised to less extent, and seems to comprise only the two first kinds or degrees of it, viz. the primary absorption of extraneous matter, and the reabsorption of certain

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Absorbent Function in Plants,

secreted matters; but in them there does not appear any power of reabsorbing what has once formed an organized part of the system. Hence the formation of organized parts in plants is not accompanied, as in animals, by the unceasing removal of old particles: but the particles, which have once become organized, continue permanent, until removed by some cause or process foreign to the living powers of the plant. When once, therefore, the organs of plants have become mature, they are exposed to decay only from the operation of foreign causes, and cannot be mined from within by that gradual loss of balance between the secreting and absorbing functions, which the advances of age bring on the animal system. Neither in the vegetable system can the removal of organized parts under disease, any more than in health, have place; and consequently, the several modes or stages of ulcerative absorption, so finely illustrated by the researches of Mr Hunter, belong not to the economy of plants.

...s very ...imple.

69. As the function of absorption is thus of more limited extent in plants than in animals, so may we expect to find the arrangement of organs destined to its exercise. In animals, the absorbent vessels are quite distinct from those which carry blood, are provided everywhere with glands, and, like the veins, are furnished with valves. From their beginnings, in all parts of the body, to their termination, they continually unite with one another into vessels successively increasing in size, until, after a long course, they form at length two trunks, which deliver their contents into the large veins near the heart. As no common reservoir exists in plants, there is no such single point to which their absorbed fluids require to be carried. Hence their absorbents seem everywhere to have a very short course, to form no union with one another, but to deliver their contents at once into the sap-vessels adjacent to them. They appear to be destitute alike of glands and valves, and indeed, in an anatomical view, they can scarcely be considered distinct from the sap-vessels, but may rather be deemed ramifications from them; so that although we grant, with Grew, that the ordinary sap-vessels do not ramify one out of another, yet they certainly send off those fine ramifications which, from their office, we denominate the absorbents of plants.

...sorbents ...he Root;

70. In the root, the absorbents are capable of being demonstrated: when a plant is immersed in coloured fluids, many of its capillary absorbents become tinged through their whole course to their termination in the sap-vessels, proving them to be simple ramifications from these vessels themselves. A farther proof of the identity of these two systems is derived from the fact, that any part of a sap-vessel is not only capable of emitting capillary absorbents from its sides, but of exercising itself an absorbent function, whenever its cut extremity is brought into contact with a fluid. These absorbents are formed very speedily, and in great multitudes on the roots of annual plants; and even in perennial plants, they appear, like the leaves, to suffer an annual decay, and be reproduced with the return of vegetation.

...in Leaves.

71. But plants absorb fluids by other parts of their surface as well as by the roots. This absorbing power extends, in some of the lower tribes, over the entire surface of the vegetable, which is destitute of any organ analogous to a root; in other instances, where the roots are small and the soil arid, the plant derives almost all its moisture by the absorption of dews through the leaves. The experiments of Bonnet show that all leaves, both those of herbs and of trees, when brought into contact with water, are capable of absorbing it, and that the moisture thus absorbed is communicated through the vascular system of the leaf. The leaves of herbs he found to absorb nearly alike from either surface; but those of trees absorbed best by the lower surface. The petiole and larger riblets appeared to absorb much less than the other parts of the leaf. So great and general is this absorbing power, that vegetables, says he, may be said to be planted in the air, nearly as they are in the earth, the leaves being to the branches what the capillary rootlets are to the roots. (*Recherches sur l'Usage des Feuilles*, p. 22, 47.)

External Absorption by Pores.

72. What then are the organs by which this function is carried on in the leaf? M. Bonnet imagined the vessels of the leaves to receive their fluids through the pores adjacent to them; and that the leaves, which had only few pores, possessed but little absorbent power. (*Ibid.* p. 20, 22.) He thought, also, that the hairs frequently distributed over the leaf, attracted moisture, and might even act as absorbents; though he admits that many leaves which have only slight inequalities on their surface, without hairs, exercise an absorbent function. (*Ibid.* p. 47.)

This subject has been since investigated by M. Decandolle, whose researches appear to confirm the account of Bonnet, as to the absorbing power of the pores. According to him, these pores are found on all parts of the leaf except the riblets, which have none, but are covered with hairs. At the mouth of the pore, a vascular net-work is always to be found, which he regards as a production from the larger vessels of the leaf. He asserts that pores are found only in those parts where vessels go to terminate, and not in others; and that in trees, this structure occurs chiefly on the lower surface of the leaf, while in herbs it is equally seen on both surfaces. The stem, in general, has few or no pores, except where it is soft and herbaceous; and even then, the pores occur only in the deeper green furrows, not on the prominent lines which bound them, and are usually covered with hairs. No pores are to be found on roots or bulbs or fleshy fruits, but most of the organs above ground are more or less furnished with them. Exposure to the air seems necessary to their formation; for plants, or parts of plants, that live beneath water or earth, are destitute of pores, but acquire them if brought into the free air. Exclusion of light prevents also the formation of pores; and hence etiolated plants are not furnished with them. (*Mém. de l'Instit. Nat.* Tom. I. p. 351.) In general, his anatomical researches, respecting the existence of pores in leaves, agreed with the results of Bonnet's experiments on the absorbing power of their surfaces; and when we consider that all plants, and parts of plants, secluded from the air, are at the same time destitute of pores, and of the power of absorbing by their surfaces, it may be inferred that the organs of absorption, on the external surfaces of

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plants, are the minute vascular productions, which in tender and succulent parts exposed to the air and light, everywhere perforate the cuticle, and form in it those innumerable orifices which we denominate pores.

Internal Absorption,

73. But the function of absorption in plants, is not confined to the taking up of extraneous matters. Many facts prove that, in every part where active vegetation exists, *internal absorption* is continually going on. The organs by which it is immediately performed cannot, perhaps, from their extreme delicacy and minuteness, be rendered capable of anatomical demonstration; but certain facts which occur in plants, coupled with certain analogies derived from other organized textures, must, we think, carry complete conviction of their existence. In almost every part, and on every surface of animal bodies, the vessels which exercise absorption may be traced; but the mouths or orifices by which they actually absorb, are scarcely ever to be seen. In one instance only, viz. in the intestines, have they been followed to their beginnings, and discovered in the act of exercising their appropriate function. (*Gordon's System of Human Anat.* Vol. I. p. 70.) But though their orifices remain, in other parts, undiscovered, no anatomist hesitates to admit their existence when he sees the canals of the vessels themselves laden with blood, or milk, or bile; and seeing them thus to convey fluids, whose colour manifests their presence, he equally believes them capable of absorbing and conveying other substances, though they may not be visible to the eye. Believing farther, that no solid part of the body, nor even fluid part that has been deposited in closed cavities, can be removed in a natural manner from its place, but by the agency of these vessels, he comes to regard the simple fact of the disappearance of such part, as sufficient evidence of its absorption.

in Seeds;

74. Now the facts and analogies on which internal absorption rests in the vegetable system, are precisely of the same nature, and the evidence of its existence is scarcely less complete. In every part of the cellular tissue of plants, various substances have been found, which must have been primarily derived from the vessels, the only organs which furnish new materials to the plant. These substances, however, often disappear from the cells, and are again to be detected in the vascular system. Thus, in the seed, as will afterwards be shown, the cells of the cotyledon contain a solid unorganized matter, which could have been originally deposited in them only by means of the vessels. During germination, this solid matter is rendered fluid, disappears from the cells, and is again to be traced in the vessels on its way to afford nutriment to the radicle and plume. We say then that this unorganized matter must have been taken up from the cells of the cotyledon, and conveyed into the vascular system, by the agency of absorbent vessels, which, it is probable, are distributed everywhere on the inner surface of these cells; just as, in the animal system, absorbent vessels are considered to take up the fat from the surface of the cells in which it is deposited, and convey it into the vessels of the animal.

in Bulbs;

75. This alternate absorption and deposition of the nutrient matter of seeds, is sometimes strikingly displayed in the growth of potatoes. It frequently happens that potatoes, lying in a damp cellar, put forth shoots which grow to a considerable size without the access of any foreign agents, except heat, water, and air. On these shoots, young potatoes, as large as the eggs of pigeons, are sometimes to be found, and the substance of the old potatoe has in great part disappeared. In such cases, the matter from the cells of the old potatoe, must be considered as removed by absorption, and conveyed into the vessels of the shoot, where it was in part employed in forming the new organs of the young potatoe, and in part deposited, to experience, perhaps, in some future growth, similar successions of removal and deposition. In the living parts of perennial plants also, nutrient matter appears to be alternately deposited and absorbed from the cells during the active periods of vegetation; and in the cellular tissue of herbaceous plants, a similar deposition and absorption of fluids seems to be frequently taking place; so that in all the vegetating parts of plants, these alternate functions of secretion and absorption are more or less constantly exercised.

76. A good illustration of the manner in which these functions are alternately exercised, is afforded by an experiment of M. Decandolle. The parasitic plant called Misletoe draws its nourishment, as is well known, from the tree on which it grows. M. Decandolle placed a branch of an Apple-tree, bearing a stalk of misletoe, in an infusion of cochineal for five days. He then dissected it, and observed the coloured liquor to have risen through the wood and alburnum of the apple-branch, and reached the place of junction between it and the misletoe, which it strongly reddened; and from thence it penetrated into the woody part of the misletoe. There did not, however, appear to be a true anastomosis between the vessels of these different plants; but, at the base of the misletoe, where the parts were so deeply reddened, a minute cellular structure was observed. Into these cells the vascular system of the apple appeared to deposit its sap, and from them the capillary absorbents of the misletoe, distributed upon the cells, seemed, like the ordinary absorbents of roots, to take it up. (*Mém. de l'Instit. Nat.* Tom. I. p. 370.) From these and many similar facts it may be inferred, that absorbents, communicating with the vessels of the plant, exist in every part, and that the removal of all secreted matters from the cells and other closed cavities of the vegetable, when effected by the living powers of the plant, is accomplished, as in animal bodies, by the exercise of an absorbent function. in Trunks.

### Article II.

#### *Of the Exhalent System.*

Organs of Exhalation,

77. But from their external surface, and from the same parts as we have seen to exercise an *absorbent* function, plants, in certain circumstances, give off a large quantity of fluid by *transpiration;* and the organs by which this function is performed, seem, from many considerations, to be the same as those by which, under other circumstances, absorption is accomplish-

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ed. This function of transpiration is common to all terrestrial plants, and all are more or less furnished with pores; but it does not occur in aquatic plants, according to Decandolle, which are destitute of pores. Fleshy plants and the petals of flowers, which have but few pores, transpire little, and etiolated plants, which are destitute of pores, do not transpire at all. On the contrary, herbaceous stems and plants, which have numerous pores, throw off most fluid by transpiration. This general agreement between the existence of pores, and the exercise of the transpiratory function, leads to the presumption that they are the orifices through which the fluids are discharged; and if it be admitted that these pores are situated at the extremity of the fine ramifications that come off from the vessels, their fitness for such an office cannot be denied. Comparing these facts, regarding transpiration, with those previously stated concerning absorption, M. Decandolle is led to conclude that the pores on the surfaces of plants are the organs by which these functions are alternately carried on, according to the existing condition of dryness or humidity in the surrounding atmosphere.

...e same as ...ose of ...bsorption.

78. Repulsive as this conclusion may at first seem to our ordinary conceptions of organized bodies, yet there are many circumstances in the structure and habits of plants that give to it great probability; so much so, that we ourselves had long since reached the same point by a route different from that pursued by M. Decandolle. It is highly probable, that the exhalents of the leaves are simple ramifications from the larger vessels, like the capillary rootlets; and as they have no valves in their canal, there is no mechanical impediment to their exercising an inverted action. The sap-vessels themselves readily absorb, even coloured fluids, when inverted; and though their exhalent terminations are too fine to receive such fluids, yet why may they not, like the trunks from which they spring, be capable of taking up ordinary fluids in that manner? The fluids absorbed through the leaves must at once enter the sap-vessels, for there is no common reservoir to which they can first be carried; and it is extremely improbable, that, from the same parts of the same vessels, exhalents and absorbents, capable of exercising only opposite functions, should at the same time arise. In the animal system, the exhalents spring from arteries, and the absorbents terminate in veins; but in the less complex structure of plants, it seems demonstrable, that both orders of vessels must at once communicate with the same sap-vessels. It is, therefore, more probable to suppose, that, instead of two distinct orders of vessels, as in animals, one only should be provided, capable, under different circumstances, of exercising different functions. This vicarious office of the organs, under consideration, leads to no confusion in its exercise; for the condition of the atmosphere, which favours transpiration, is that which removes from the leaves the power of absorption; and, on the contrary, absorption occurs only in a humid atmosphere, when, as Hales has shown, little or no transpiration takes place.

I...rnal S...creting

79. The view thus presented of the *external* absorbent and exhalent vessels, may probably be extended to the minute vascular productions which seem everywhere to spring from the vessels *internally*. If secreting and absorbing vessels be held to exist in every part of the plant, they must everywhere communicate with the vascular system; for it is from the vessels of this system that the matter of their secretions is primarily derived, and it is into the same vessels, that, in many cases, these secretions are subsequently returned. Nor does the exercise of the two functions of secretion and absorption in plants present any apparent obstacle to the supposition of their being performed, at different times, by the same organs. Thus, when nutrient matter is deposited in the cellular tissue of the seed, it is destined only for a future use, and the purpose of nature would be defeated, were an absorbent function to be, at the same time, employed for its removal. On the other hand, when this matter is again taken up, during the germination of the seed, no secreting function seems then to be exercised in that part; for the organ itself, in many seeds, gradually wastes, and no fresh matter is deposited in it. Even when the cotyledon, to a certain extent, augments in size, its nutrient matter is continually drawn off for the support of the radicle and plume, and no fresh matter of the same kind seems to be then deposited; so that the same vessels, which formerly exercised the function of secretion, may, without disturbing the economy of the plant, be now employed in the exercise of absorption. As thus the two functions do not require to be performed, in the same part, at the same time, they may, if nothing else forbid, be exercised at different times by the same organs. In the animal system, where the organs themselves are removed, secreting and absorbing vessels must necessarily co-exist; and to maintain the integrity of parts, their functions must proceed at the same time, and, to a certain extent, balance each other; but, as no similar operations appear to be carried on in the vegetable system, no such complex organization is required to sustain them.

Elementary Organs. and Absorbing Organs.

## Section III.

### *Of the Cellular Tissue.*

#### Article I.

#### *General Description and Character of the Cells.*

Definition.

80. The elementary organ, denominated *cellular tissue*, may be said to consist of a membranous substance, disposed into a great number of small circumscribed cavities, connected with each other, and arranged in rows or suites, generally in a direction that cuts at right angles, the perpendicular tubes which represent the vascular system. From Grew, it received the appellation of *parenchyme*, a term still often used in describing different parts of this tissue; by Malpighi, it was called the *utricular substance*; and it owes, we believe, its present name to M. Du Hamel.

Description.

81. The cavities which distinguish its construction were called indifferently bags or bladders, pores and cells, by Grew; by Malpighi, utricles; by others,

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vesicles; and more commonly cells. The form of these cells varies so much, not only in different plants, but in different parts of the same plant, as to have authorized, in some degree, these different appellations. The tissue which they constitute, enters into the composition of every organ in the more perfect plants. Of many herbaceous plants it forms the chief portion, and some of the lower tribes of vegetables are said to be wholly composed of it; in other words, no vessels can be actually demonstrated in them. In most cases, it contributes greatly to modify the form of organs, and adds always to their bulk and strength. Nothing can exceed the diversity of appearance in figure, bulk, and texture, which it exhibits in the several parts, circumstances, and conditions in which it is placed. It represents sometimes a lax cellular substance, all the parts of which are succulent and transparent; in other instances, it is compressed into a solid opaque body, retaining but faint traces of its former cellularity; and in others again it is spread out into a most thin and delicate membrane, in which the cellular character is wholly lost. It everywhere envelopes and holds together the vascular system, and seems to be the general receptacle of almost all the vegetable secretions.

Figure of the Cells;

82. The figure of the component cells of this tissue is exceedingly various. Sometimes they have nearly a globular or spheroidal shape; in other instances, they are angular, and exhibit, in their section, a greater or lesser number of sides and angles, being in a few examples triangular; in others, square, but more commonly hexagonal; the figure which collections of soft cells, mutually impressing each other, seem naturally disposed to assume. This form is represented in the transverse section of cells, fig. 20. A. Plate XV.; they seem, in this figure, and in most of those given in different works, to possess double sides; but as M. Kieser has remarked (*Mém. sur l'Organisat. des Plantes*, p. 91.), this appearance is produced by the borders of the subjacent cells being seen through the transparent sides of the superior layer. In Plate XVI. fig. 22. is a representation of a transverse slice of the cellular part of Sugar-cane, drawn from nature, and so thin as to exhibit only one layer of cells, in which the sides appear distinctly single; but, in a thicker slice of the same plant, fig. 23. comprehending more than one layer, the double appearance becomes very evident.

their Size;

83. The size of the cells varies not less than their figure in different plants, and in different parts of the same plant. In one of the plates of Grew, they are represented as possessing twenty different sizes, from that of a minute pore, to the size of a common pea. Hooke examined them in Cork, and in the pith of many plants. In Cork, he reckoned several lines of these cells, or pores, as he calls them, and found there were about sixty placed endwise in one-eighteenth part of an inch, or somewhat more than a thousand in the length of an inch; and, therefore, in a square inch above a million, and in a cubic inch above 1200 millions. (*Micrographia*, p. 114.) In this substance, the cells are not visible by the naked eye, but become very distinct when highly magnified. In most plants, however, they are readily visible, and their appearance is familiar to every one.

84. When viewed in a longitudinal section, their hexagonal form is much less distinct, and is sometimes wholly lost. In fig. 24. Plate XVI. is a series of single columns of the cells of sugar-cane, in which each cell is, to appearance, bounded only by four sides. Similar representations are given by Hooke of the cells in Cork, and by Kieser, in most of the figures which exhibit longitudinal sections of the cellular tissue; but, in some instances, the hexagonal form is visible even in these sections. In fig. 25. of the same plate, we have given, in outline, the appearance of two series of columns of these transparent cells, in which one series is seen behind the other, and gives somewhat of the confused double appearance exhibited in the transverse section, fig. 23.

Contents;

85. The nature of the matter contained in the cells of this tissue, varies according to the part in which it exists, and the peculiar powers of the plant. Both Hooke and Grew remarked, that, in the pith and bark of succulent plants, the cells were often filled with aqueous juices, and in the same plants, at other periods, they appeared empty, or filled only with air. In the seed, the cells of the cotyledons contain minute unorganized particles which, at a future period, serve as nutriment for the young plantule. Other particles of still smaller size, of a resinous nature, and a green colour, exist in other parts of this tissue, and bestow on the plant its verdure. In every part of the plant, these cells are also the occasional receptacles of the peculiar fluids which both the sap-vessels and the proper vessels convey; and hence various gummy and resinous substances, corresponding in quality to the fluids previously existing in the vascular system, are frequently detected in them. In the pulp of fruits, the various acid, saccharine, and austere juices that we meet with, are contained in different modifications of this tissue; and it is into its cells that the osseous secretions, which constitute their shells and stones, are made. These facts prove not only the great importance of this tissue in the construction of the vegetable organs, but the active share it bears in the economy of their functions, and demonstrate likewise an universal communication betwixt the vessels and the cells.

Structure;

86. The sides of these cells, when emptied of their contents, and viewed through the microscope, appear to be formed by a very fine transparent membrane, which some maintain to be everywhere entire, and others to be perforated with pores. The same sources of error exist here as before noticed in similar microscopical observations on the vascular system; and, accordingly, the respective disputants maintain, with equal confidence, the same opinions with regard to the porosity or non-porosity of the cells, as they had previously held concerning the vessels. We must therefore call in the aid of other means besides those of the microscope, for determining the important fact, whether the cells have or have not any direct communication with each other.

are close Cavities.

87. Dr Hooke examined the films or sides of the cells of Cork, of the pith of Elder, and of many other plants, with the very purpose of discovering

6

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whether any direct communication existed between them; but "each cavern or cell," says he, "is distinctly separate from the rest, without any kind of hole in the encompassing films;" nor could he, with his microscope, nor by his breath, nor by any other way that he tried, "discover a passage out of one of those cavities into another." (*Micrographia*, p. 116.) Dr Grew describes the little cells or bladders that compose the bark of roots, as possessing a spheroidal shape in most plants. When viewed with the microscope, their sides are as transparent as water; and "none of them," he adds, "are visibly pervious from one into another, but each is bounded within itself." (*Anat. of Plants*, p. 64.) Both Hooke and Grew, however, believed a communication to exist between the cells, from the fact of their containing liquor; and Malpighi held the same opinion from similar considerations; but they nowhere describe the mode or structure by which they conceived it to be accomplished.

88. Later writers have not only adopted this opinion, but professed to demonstrate the structure by which the communication is maintained. M. Mirbel describes the sides of the cells as composed of an extremely thin, colourless, and transparent membrane, which is commonly perforated with pores, the diameter of whose aperture is not, perhaps, the 300th part of a millimetre. These pores are ranged generally in transverse series, and through them, it is said, the cellular tissue both receives fluids from the vessels, and transmits them very slowly through its cells. (*Exposit. de la Théorie*, &c. p. 105.) M. Sprengel, and some others, adopt this view of the porosity of the cells; but it is denied by Link, Treviranus, and Kieser. The latter author declares, that, "notwithstanding all that has been said concerning the pores in the sides of the cells, his observations, made with the greatest care and exactness, have not enabled him to discover the slightest trace of them." The sides of the cells, he adds, are always formed by a membrane extremely thin, but altogether smooth and uniform; and "the cells themselves have never an open communication with each other." (*Kieser sur l'Organisat. des Plantes*, p. 94.) In a critique on M. Mirbel's doctrine, he farther observes, that, although possessing eyes extremely piercing for microscopical objects, and employing the highest magnifying powers, he has never been able to discern, in the membrane of the cells, the existence of pores, though he sought for them with the greatest care and precaution." (*Ibid.* p. 29.)

Have no Pores.

89. From the results, therefore, of direct experiments employed to discover the porosity of the cells, as well as from the combined reports of the most accurate microscopical observers, we must pronounce against the opinions of M. Mirbel; and although he has delineated the form and position of the pores, computed their number, and even measured their apertures, it may, we think, be asserted, that he has either been deceived himself, or has exhibited, as real copies of nature, forms and structures which never had existence but in his own imagination. This charge seems accordingly to have been preferred by some of his opponents; and, in the preliminary observation to the explication of the figures in his last work, he comes forward with this reply to it: "Pour éviter désormais toute espèce d'équivoque, je dois prévenir que les parties que je nomme *organes élémentaires*, ne se présentent jamais isolément dans la Nature. Je fais donc ici ce que j'ai fait dans mes descriptions; je divise par une opération de la pensée, ce que la Nature n'offre que réuni; et je montre, non pas rigoureusement ce qu'on peut voir, mais ce que la reflexion, guidée par l'observation et l'expérience, présente à l'esprit. N'est-ce pas là le résultat de l'analyse philosophique?" (*Exposition*, p. 114.) he exclaims! We answer, that, in cases of this sort, we want the fair transcript of the object itself, and not the analytical result of the author's speculations about it; and we hold it not only unphilosophical, but something worse, knowingly to have given, as faithful copies of Nature, representations of the elementary organs, which, as M. Kieser remarks, are designed not from Nature, but from imagination. (*Mém. sur l'Organisat. des Plantes*, p. 77.)

Mode of Communication.

90. If, then, no pores exist in the sides of the cells for the reception and transmission of the fluids they contain, some other means must be provided for the accomplishment of these objects. M. Link, accordingly, supposes the juices to pass from one cell to another by *transudation* through *invisible pores* in their sides,—a supposition which will scarcely be admitted by physiologists as applicable to *living* organized textures. And M. Rudolphi suggests the still more extravagant opinion, that a *decomposition of the fluid* is effected by the cells themselves, during which it is transmitted through their sides. (*Mirbel's Exposition*, &c. p. 183.) To us there occur no other means of accomplishing these operations, consistently with the integrity of the cellular structure, than the exercise of those alternate functions of secretion and absorption, which, from so many other considerations, we have supposed to be carried on in every living part of the vegetable system.

Sides of the Cells.

91. Another question of less improtance in relation to the sides of the cells is, whether they are single or double; that is, whether each cell has a side of its own, or whether one side is in every position common to two cells. Mirbel asserts the former, and Kieser maintains the latter opinion. In fig. 20. B. Plate XV. is an outline representation of these double sides as given by Kieser. From the extreme thinness of the membrane, it is very difficult, he says, to distinguish this double structure; but where the cells are large, and a glass that magnifies highly is employed, each partition that separates two cells is distinctly seen to be composed of two membranes, which are sometimes separated about the middle of the partition, and united towards the angular points. (*Mém. sur l'Organisat. des Plantes*, p. 91.) The existence of this double structure receives some countenance from the fact lately observed in the construction of the honeycomb by Dr Barclay, who says that each side of every cell in the comb is composed of two plates, or is double. (*Wernerian Transactions*, Vol. II.) It may still, however, be more properly said, that each side of every cell is truly single, and is rendered double only by coming into contact with the corresponding side of an adjacent cell.

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Intercellular Canals.

92. When the cells have a regular hexagonal figure, and are equally distended with their appropriate juices, there is no reason to suppose that any vacuities are left between their sides or angles. Mathematicians have long since demonstrated a regular hexagon to be one of those figures that completely fills up a given space; and that no vacuities can exist either about its sides or its angles. Where, however, the cells deviate from this regular figure, and more or less approach to a spherical form, vacuities or interstices may readily be conceived to occur. These vacuities are said to have been first noticed by Leuwenhoeck, and afterwards by M. Treviranus, who describes them as interstices left between the cells in their mutual approximations towards each other: He gave them the name of *intercellular canals*, and considers them as the only passages by which the fluids can be conveyed through the cellular tissue. (*Kieser's Mém. sur l'Organisat. des Plantes*, p. 20.)

93. On the other hand, MM. Mirbel and Rudolphi, altogether deny their existence; but M. Kieser contends strenuously for it. He describes them as small interstices situated at the angles of the hexagonal cells, and formed not by any sides of their own, but by the mutual approach of three contiguous cells, and possessing, therefore, a prismatic form. These interstices, he conceives to exist at every angle, and thus every cell to be surrounded by them. In fig. 20. B. Plate XV. the black angular points denote their place. By their conjunction with each other, they form a canal, which, when the hexagonal figure is perfect, and the cells are ranged horizontally, extends both in a longitudinal and transverse direction; and when the cells are placed obliquely, then the canals have a similar direction. Their size varies according to that of the cells, by the sides of which they are constructed; they contain and convey the proper juices in the bark, but in the pith are often dry; and their course is said to terminate only with that of the cells themselves, at the surface of the plant. (*Mém. sur l'Organisat. des Plantes*, p. 104.) Such are the organs which, as we have seen, M. Kieser considers to convey both the sap and the proper juices in plants; and which he describes as produced universally by that form of cell, which, of all others, is most calculated to exclude their existence. That, in some circumstances they may exist, and become reservoirs of the sap, or other juices, seems highly probable; but of the absurdity of ascribing to such casual productions, the performance of the primary functions of the vegetable system, we have already spoken.

Changes of Form in the Cells.

94. The cellular tissue, as described above, is that form of it which must be regarded as the most perfect. From various causes, however, it is subject to great alterations. In herbs, and in the pith and succulent parts of trees, the cells preserve their original form and appearance for a considerable time; but, by the growth of the other parts, and consequent extension and compression they experience, they acquire in the bark and wood an elongated figure, and this both in a transverse and longitudinal direction. In the latter case, they surround and connect the layers of vessels with each other, constituting what has been named the *parenchyme* of the bark and wood. In this form, their size is often greatly reduced, their cavities sometimes obliterated, and their cellular character altogether effaced. In other instances, traces of a cellular structure are occasionally visible, appearing in detached portions among the perpendicular vessels. In plants of very rapid growth, the cells are said by Kieser to become elongated in a longitudinal direction, and yet preserve their capacity nearly unchanged; so that the tissue which they form appears as if composed of a number of small cylinders. It was probably this construction that led Malpighi to regard sometimes as vessels, what, in reality, appear to be only a collection of these elongated cells. His error appears, however, but slight, compared with that of M. Kieser, who considers the bark as altogether constructed of these elongated cells, somehow metamorphosed into cortical fibres, and interlaced by other similar cells extending in a transverse direction. The wood, too, he supposes to differ in construction from the bark only in possessing spiral vessels; its ligneous fibres he farther holds to be formed by the sides of the aforesaid elongated cells, where the intercellular canals have disappeared; and, as the spiral vessels, according to him, convey only air, no other organs remain for performing the office of sap-vessels but the intercellular canals. (*Mém. sur l'Organisat. des Plantes*, p. 99, 101.) But there is a wide difference between the observations and the opinions of M. Kieser;—the former we regard generally as laborious, minute, and faithful;—the latter often appear to us crude, inconsistent, and absurd.

95. From suffering compression in a transverse direction, the cells have frequently their longer diameter thrown into that position, and thus extend from the centre to the circumference of the plant. This disposition, as will afterwards be shown, was fully noticed by Grew and Malpighi. Leuwenhoeck also observed it, but mistook the cells, as Malpighi had done, in the opposite direction, for vessels, and considered their partitions as valves—errors which M. Kieser, as well as others, duly points out, and yet, as we have just shown, similar to that into which he himself has fallen. In this transverse direction, the tissue forms partitions more or less large between the vessels, as will afterwards be shown, and by the obliteration of its cells, it is frequently reduced to the condition of a solid membrane.

Ruptures of the Cells.

96. Beside these more constant and necessary changes in the figure and character of the cellular tissue, it often suffers others of a more casual and accidental nature. In the pith, as the plant grows up, divers ruptures, says Grew, occur, oftentimes very regularly, and observed constantly in the same species of plant: these ruptures are sometimes prolonged, so as to form a tube of considerable length. (*Grew's Anatomy of Plants*, p. 120.) Others have observed similar canals in the pith, formed not by sides of their own, but by those of the adjacent cells, and very various in size and form: they have been called *lacunæ* or reservoirs, contain a variety of substances, and sometimes, especially in aquatic plants, only air. As we have seen the cavities of the larger spiral vessels to be filled with vesicles, so the larger cells of the pith, according to Grew, frequently con-

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tain smaller ones, or are divided by cross membranes. A similar observation is made by Kieser, who likewise remarks, that, in the empty cells of *Calla Æthiopica*, he has sometimes seen small round-headed bodies, supported on little peduncles, which spring from the sides, and point towards the centre of the cells. Small crystallized bodies are also occasionally found in the cavities of the cells, and within the intercellular canals. (*Mém. sur l'Organisat. des Plantes*, p. 94.) Of those changes in the character of the cellular tissue, by which its cells are converted into receptacles and reservoirs of the proper juices of the plant, we before discoursed when treating of the proper vessels. To such an extent does this change sometimes proceed, that, in aged Oaks, and, according to Kieser, in Guiacum, and probably in many other plants, the whole cellular tissue becomes filled with these secreted matters, and the distinctive characters of the cells, and almost of the vessels themselves, are obliterated and lost.

Cells contain Vesicles.

### Article II.

*Of the Structure and Formation of the Cellular Tissue.*

Formation of the Cells.

97. But anatomists have not confined themselves solely to descriptions of the more obvious forms and characters of this tissue: they have attempted to penetrate into the secret of its ultimate structure, and, deserting thus the beaten path of observation and of sense, have wandered at large through the regions of imagination. It would be a waste of time to pursue, to any considerable extent, these vagaries of the fancy; but a brief notice of a few of them may afford some amusement, and perhaps instruction, to the reader.

98. It seems pretty generally admitted, that the tissue, of which the cells are constructed, partakes of a membranous nature; and the first question therefore is, of what materials is this membrane composed? Grew considered the cells, as well as the vessels, to be formed of exceedingly minute fibres, which were themselves tubulous, or rather smaller vessels. (*Anatomy of Plants*, p. 76, 77.) Malpighi deemed the thin membrane that forms the cell to be produced from an effused juice, that gradually acquired solidity, and was everywhere furnished with a reticulation of vessels. (*Anat. Plantar.* p. 29.) According to Du Hamel, the constituent part of this membranous structure is rather to be regarded as filamentous than vascular; though he admits, that, in fleshy fruits the vessels of the cellular tissue are so numerous that they seem to form the cells themselves. (*Phys. des Arbres*, Tom. I. p. 15, 24.) In the leaf, the elder De Saussure maintained, that what is called the cellular part is formed entirely of minute transparent vessels, which, between their junctions, swell out so as to give the appearance of cells or vesicles, though in reality they are a net-work of vessels. (*Encyclop. Méthod.* Tom. I. Art. Parenchyme.)

Opinion of Grew; of Malpighi; of Du Hamel; of De Saussure.

99. The manner in which these primitive vessels or filaments have been employed to form the membrane, has likewise been differently conceived by different writers. Grew imagined them to be disposed in opposite directions, like the warp and woof of the weaver's cloth, and everywhere knit together by the weftage of other fibres. Du Hamel could see no such regular structure, and therefore believed them to be united promiscuously, like the filaments in a piece of felt; and Malpighi and Saussure seem to have regarded them as joined together in the form of net-work.

100. Not less different have been the modes in which this membranous substance, during or after its formation, has been supposed to acquire its cellular figure. Grew seems to have thought that the figure of the cells was determined by the course which the vessels pursued in their formation; hence he remarks, that while the vessels proceed circularly, and keep within the compass of the cells, the cells are round; but where they wind out of one cell into another, then an angular form is produced. (*Anatomy of Plants*, p. 77.) Later observation, however, has rendered it probable that the angular form is the result rather of the mutual pressure which the cells subsequently exert on one another, than communicated during their formation. The general appearance which a mass of cells exhibited after their formation, he resembled to that of the froth of beer (*Ibid.* p. 67.); but never, as some seem to have supposed, imagined them to be produced by a similar operation. By all those who maintain the vascular nature of the cellular tissue, the cells must be considered as originating from the vessels—an opinion frequently advanced by Malpighi, who particularly describes the excrescence on the leaf of the Oak, called gall-nut, as composed of a cellular structure, which is derived immediately from the vessels of the leaf, and which opinion, as he justly remarks, the structure of the leaf itself, of the flower, and the fruit, hereafter to be described, will illustrate and confirm.

Opinion of Ludwig; of Mirbel.

101. A different view of the origin and formation of cells has been taken by others. Ludwig conceived the vessels, as well as the cells, to derive their origin from a common membrane, but does not describe the manner in which the cells and vessels could be produced out of it. (*Institut. Phys. Regni Végétab.*) This opinion has since been adopted by Mirbel, who considers it as perfectly original; and has gone more into detail regarding the mode in which cells and vessels are produced. According to him, the entire mass of the vegetable is a membranous tissue, the ultimate structure of which he does not pretend to explain, and out of this tissue the small cavities called cells, and the vessels are alike formed. He of course denies the independent existence of cells and vessels, and of the vascular productions or fibres by which these two organs have, by others, been supposed to be united: and maintains that the entire vegetable is constructed of one continuous membrane, between all the parts of which a communication is kept up by means of innumerable pores. (*Exposit. de la Théorie de l'Organisat. Végét.* p. 60, 62, 279.) How this membrane acquires the varied and regular forms which it exhibits in the cells and vessels of the plant, we are not distinctly told. All that we can discover on this point, is, that the cells are not distinct sacs or utricles, but produced out of a membrane which unfolds itself (se dédouble) in some inconceivable manner, so as to leave empty

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spaces contiguous to one another, which constitute the cells. (*Traité d'Anat. et Physiol. Vég.* Tom. I. p. 56.) The mass of cells thus formed, is considered very similar to the vesicles of the froth of beer, with which Grew had previously compared it: for the thin transparent plates of these vesicles are said to be everywhere continuous, and each side to be common to two vesicles, while all interstices or intercellular spaces, and all connecting vessels and fibres, are completely excluded. We are also told that the smaller vessels are only elongated cells, and the larger ones cavities formed in the cellular tissue; so that this tissue must be regarded as the essential organ of vegetables, and the other organs are but modifications of it; and in this way M. Mirbel passes off the assertion of an opinion for an explanation of the mode in which the vessels are constructed.

Opinion of Sprengel;

102. Instead of the continuous mass of cells which Mirbel professes to describe, M. Sprengel conceives the cells of this tissue to originate from elementary globules, such as are found in the cotyledon of the bean, which at first seem a chaotic mass of extremely minute vesicles, but are gradually developed, and acquire an angular form. This seems likewise to be the opinion of M. Treviranus, who regards the cells as originating from the aforesaid cotyledonous vesicles, which have at first a round form, but are changed afterward by the effect of pressure; these vesicles are supposed gradually to extend, to close towards each other, and in this way to construct the tissue. The elementary vesicles, however, out of which these writers construct their cells, are justly regarded by M. Link (*Kieser's Mém. sur l'Organisat. des Plantes*, p. 17, 19, 23.) as globules of starch deposited for the future nutriment of the embryo.

of Treviranus;

of Kieser.

103. M. Kieser also derives the origin of the cells from primitive globules, but looks for them in a different part of the vegetable system. In the proper juices of plants, certain minute particles or globules have been observed, which, according to this author, are the rudiments of future cells, or rather, says he, true cells themselves, though extremely minute. An infinite number of these globules exist in the proper juices, which juices are present in every primitive utricle. Gradually these globules dilate, approach, and are soldered to each other, receiving by their reciprocal pressure an hexagonal figure, and thus constructing the cellular tissue, which is nothing but a parenchyme of many small cells, enclosed in a great cell, or primitive utricle. Each cell, therefore, of the cellular tissue is, in its origin, only a transparent globule, which becomes filled with fluids, and soldered to the adjoining cells, so as to form an entire piece, the parenchyme of the plant. As this dilatation of these primitive globules is, in all cases, the first function of the plant, the cellular tissue is the first and primitive organization of the plant, from which proceed afterwards all the other elementary organs. (*Ibid.* p. 219.) Such is M. Kieser's account of the origin of the cellular tissue, which, as we think, surpasses in absurdity that of M. Mirbel, whose doctrine he so justly condemns;—but so much easier is it to "see the mote in our brother's eye," than to be conscious of the "beam in our own."

Common Textures.

## CHAP. II.

### THE ANATOMY IN GENERAL OF THE COMMON TEXTURES OF VEGETABLES.

*Preliminary Observations.*

Nature of the Common Textures.

104. The elementary organs, whose description has so long occupied our attention, form, either singly or by their combination, all the other parts of plants. Some of the lower tribes of vegetables consist entirely of cellular tissue, in which no vessels are at any period to be seen; and, even in the higher orders, many parts exhibit no appearance of a vascular structure. There can be little doubt, however, of the existence of such a structure, since, physiologically speaking, we can form no just conception of the growth of an organized body, without associating with it the existence of a vascular system. In all plants, the pith consists of cellular tissue alone. In herbaceous plants, this tissue forms their greater portion; but in trees, the number of vessels is so great, as to constitute the chief bulk of the plant. To certain forms of these elementary organs, whether existing singly or in combination, we have given the name of *common textures*, because they are very generally to be found in all plants, and in almost all parts of them, howsoever varied in quantity, proportion, and arrangement. These textures are familiarly known under the names of Cuticle or Skin, of Bark, of Wood, and of Pith; to which may be assigned the general appellations of the Cuticular, the Cortical, the Ligneous, and Medullary textures.

Their Position various.

105. All the several textures just enumerated, are readily distinguished, by their different places and characters, in the section of most arborescent plants, in which they commonly appear well defined, and perfectly distinct from each other. In many plants, however, both herbs and trees, this distinction of parts is not preserved; but, with the exception of the cuticle, all the other textures are blended together through the entire substance of the plant, as was long since noticed both by Malpighi and Grew. "In the stalk of maize or Indian wheat," says Grew, "the work of nature appears less diversified; in which, although there are the same parenchymous and ligneous parts, as in all other plants, yet is there neither bark nor pith, the vessels being dispersed and mixed with the parenchyma, from the circumference to the centre of the stalk." "The like structure," he adds, "may also be seen in the Sugar-cane, and some other plants." (*Anat. of Plants*, p. 104.) Similar observations were made by Malpighi, not only on different species of wheat and sugar-cane, but on ferns and palms. "In Ferns," says he, "the vascular fasciculi are numerous, but placed without order, and are everywhere sustained by the intervening cellular tissue, the cells of which are sometimes much smaller than the orifices of the vessels themselves." (*Anat. Plantar.* p. 24, 25.) This structure is represented in the transverse section of the sugar-cane, Plate XVI. fig. 26.; and in a similar section of the palm, fig. 28. of the same Plate.

Common Textures.

Theory of Desfontaines.

106. This variety of structure, thus clearly described, and distinctly delineated in the works of Malpighi and Grew, has lately been noticed by M. Desfontaines, who deems it common and peculiar to all plants, whose seeds have but one lobe or cotyledon; while all plants produced from seeds that have two cotyledons, are held to possess a very different arrangement of parts. Vegetables, according to him, may be distinguished into two divisions: 1*st*, Those which have no distinct concentric layers, whose solidity decreases from the circumference towards the centre, and whose pith is interposed among the vessels, and does not extend in divergent rays. 2*d*, Vegetables which have distinct concentric layers, whose solidity decreases from the centre towards the circumference, and whose pith is contained in a longitudinal canal, and extends in divergent rays. The former structure he considers as peculiar to plants, whose seeds are monocotyledonous, and the latter as belonging to those which have dicotyledonous seeds. (*Mém. de l'Institut. Nat.* Tom. I. p. 478.)

Not just.

107. There does not, however, appear any just ground for this supposed coincidence of structure betwixt the seed and the stem. That many plants which spring from monocotyledonous seeds, are destitute of concentric layers, and have no distinct bark or pith, is most certain; but it is not less certain that many herbaceous plants, which are produced from dicotyledonous seeds, are pretty much in the same condition, being equally destitute of concentric layers, and of divergent rays; and in which the bark and the pith must be regarded as one continuous structure. On the other hand, some monocotyledonous plants, as M. Desfontaines admits, may deviate a little from the prescribed conditions. In a paper on the organization of such plants, M. Mirbel, who regards this doctrine as the most important step made of late years in Vegetable Anatomy, says, nevertheless, it would be erroneous to assert that they have never a bark. In several species of plants, he produces examples to the contrary; and adds, that, in some instances, their diametral growth goes on at the circumference, which would seem to approximate them to dicotyledons. As, however, there is no appearance of divergent rays, or of concentric layers, these examples are considered by him rather to confirm than overturn the theory of M. Desfontaines. (*Annales du Mus. d'Hist. Nat.* Tom. XIII. p. 67.) But if, in this theory, its second division embrace only those plants in which the concentric layers are perfect, and divergent rays exist, then it excludes a great number of herbaceous plants, whose seeds have two cotyledons; and if the absence of these regular layers, and of divergent rays, serve as a passport to the first division, then many of these same plants must be admitted among those whose seeds have but one cotyledon. The theory of M. Desfontaines, therefore, rests on too partial an observation of the structure of plants. All that is true in it was previously known, and all that is new will not serve the purpose of its author. For the former part, he has omitted to do justice where it was due; for the latter, he has received extravagant praise where it has not been deserved. It has been our wish to render equal justice to all.

108. Instead, therefore, of seeking to found the structure of the stem on the form of the seed, it will be more correct to describe the several varieties of its appearance, as they actually present themselves on dissection; beginning, as Grew and Malpighi have done, with the more simple arrangement of the elementary organs, as they occur in certain plants, and following them, through their several gradations, to more precise and better defined forms. Although some of these plants do not, properly speaking, possess either distinct bark or pith, yet no misapprehension can arise from treating of these parts under the denomination of *common textures;* for though not universally, they are very generally, present; and even where they are not, the descriptions will, with little variation, apply to such structures. As of these common textures, the pith is the most simple, we shall commence our account of them with a brief description of it.

Common Textures.

## Section I.

### *Of the Pith or Medullary Texture.*

109. The pith (medulla) of plants when present, occupies the centre of the stem, where it is commonly surrounded by a circle of vessels which construct for it an appropriate canal. In the succulent shoots of trees, its proportion to the other parts is generally large; but it diminishes as the tree advances in age, and is frequently entirely obliterated. Where the vessels of the wood are few in number, as in herbs, only a few fasciculi are seen to surround the pith, and the intervening spaces are occupied by a boundary of thickened cellular tissue. In some plants again, no pith whatever exists, but the stem is hollow or tubular. In other instances, and especially in roots, the centre of the stem is occupied by vessels; and in others, both cells and vessels, promiscuously blended together, constitute the centre of the stem. The Pith.

110. In those plants where the pith is present, and possesses its most perfect form, it is seen to be composed entirely of cellular tissue, possessing often very different shades of colour, but, in its anatomical characters, resembling exactly the description already given of that tissue. Its bulk, in different plants, is exceedingly different, as are also the form and size of its cells. It is frequently entirely insulated by the surrounding vessels, but is often continuous with the cellular tissue of the bark. Its cells contain, especially in the early age of the plant, aqueous fluids which afterwards disappear, and then the cells become filled only with air. The proper juices of the plant may also be sometimes detected in the cells of the pith. Of the ruptures produced in it by desiccation and other causes, we have already spoken in discoursing of the cellular tissue; they occur particularly in succulent plants, where the cells are large, and their sides thin; so that, as the plant advances to maturity, the pith breaks and shrinks up, making the trunk a pipe. (*Grew's Anatomy of Plants*, p. 129.) We have also noticed the fact, that, within the cavities of the larger cells of the pith, new vesicular productions are sometimes found. Description.

Common Textures.

Vessels in the Pith.

111. Grew speaks of the existence of vessels in the pith of certain plants, as in that of the Fig and the Pine; but he adds, that they are usually so postured as to form a ring about its margin. (*Anatomy of Plants*, p. 119.) They are doubtless to be considered as enlarged *proper vessels*, which made a part of the first ligneous circle, and have retained therefore nearly the situation in which they were originally formed. Hence, as he observes, they are of divers kinds, answerable to those of the bark, containing, in the Fig, a milky juice, and in the Pine, a resinous substance. Similar vessels, containing a proper juice, were observed also in the pith of Elder by Malpighi, who seems to regard such appearances as common, where the contained juice concretes, or possesses a dark colour. (*Anat. Plantar*. p. 4.) It is probable, however, that the organs here considered to be vessels, may, in some cases, be cells, into which these juices have been poured; but where real vessels of this kind are found, they are not to be considered as a part of the original structure of the pith; but occurring only in consequence of the changes, which the vegetable body undergoes in the progress of its growth.

Its Nature.

112. The general nature of the pith is thus clearly announced by Grew. "Although," says he, "it have a different name from the *parenchyma* in the bark and the *insertions* in the wood, yet, as to its substance, it is the very same with them both; whereof there is a double evidence, viz. their continuity, and the sameness of their texture;" so that all these parts are "one entire piece of work, being only filled up, in divers manners, with the vessels." (*Anat. of Plants*, p. 119.) This continuity of the pith with the cellular tissue of the bark, by means of the insertions or transverse ranges of *utriculi*, as he calls them, is also adduced by Malpighi as evidence of the similarity of their nature, and of the pith being, as it were, an intercepted portion of the bark (*Anat. Plantar*. p. 4—30.); an opinion which seems abundantly confirmed by the intermixture of the medullary and cortical textures in many plants, in which, as already remarked, the distinctive characters of bark and pith are alike lost, and the entire stem exhibits only one uniform appearance of structure.

Errors concerning it.

113. The term *medulla*, employed by the ancients to denote this texture, derived its origin, no doubt, from the resemblance which the pith, in the centre of trees, bore to the marrow in the bones of animals; and as the same term, in Animal anatomy, was incorrectly employed to express alike the marrow in the bones, and the nervous substance in the vertebral column, so the same latitude of signification has been extended to the vegetable system. Hence, as Malpighi remarks, the medulla in vegetables was regarded as analogous, in its nature, to the brain of animals, a doctrine which even later writers have continued to espouse. It is not our present intention to describe the uses of the pith, but only to remove erroneous opinions concerning its nature, and restore to it that just anatomical character, long since assigned it by Malpighi and Grew; and which some writers have of late put forth as a considerable novelty.

### Section II.

#### *Of the Wood or Ligneous Texture.*

Common Textures.

The Wood

114. Immediately surrounding and enveloping the pith, is the part called the wood (*lignum vel lignea portio* of Malpighi.) It is essentially composed of vessels and of cellular tissue, but combined in such an infinite variety of proportions, and exhibiting such a boundless diversity of forms, that it is difficult to seize even its more general features, without the risk of extending our descriptions beyond the limits which our plan necessarily prescribes.

Description.

115. Except in those vegetables in which no vessels have been hitherto demonstrated, but in which they must nevertheless be presumed to exist, this texture may be considered to form a part not only of every plant, but of all its organs; for into whatever part fluids are conveyed, vessels must be supposed to extend; and wherever vessels are present, cellular tissue is to be found: hence, in its distribution, it may be considered the most universal of all the textures. In trees, the vessels, as we have frequently remarked, are very numerous, and, when viewed in a transverse section, are seen to be disposed in layers or concentric circles around the axis, and to stand also in lines or radii, diverging from the centre of the tree. See fig. 4. Plate XVII. Between each line or ray of vessels, a thin partition of cellular tissue is interposed, which extends in the direction of the ray, through the entire substance of the wood. At certain distances, varying in different trees, thicker transverse portions of the same substance are placed, and are readily distinguishable in almost every species of wood. Between each layer that is annually added to the wood, and each of the smaller layers that go to the formation of the larger one, cellular tissue seems also in some trees to be longitudinally interposed; so that it is probable, that, in both directions, each fasciculus of vessels is intercepted by cellular tissue, and that in such trees no two fasciculi are on any side in immediate contact with each other. It is even probable, that the individual vessels which contribute to form the fasciculi, are themselves connected by intervening cellular tissue, which acts like the *neurilema* that holds together the filaments of the fasciculi in the nerves, or the cellular substance that connects the primary filaments in the muscular fibres of animals. In this manner, the whole vascular system of the plant is everywhere connected and held together by cellular tissue. Of this tissue, and the different figures its cells acquire, from the different modes and degrees of compression to which they are exposed, we have already spoken.

In ordinary Trees.

In Palms.

116. In many trees, however, as Palms, the vascular fasciculi, though numerous, are much less abundant than in the examples just referred to. They are consequently placed at a greater distance from each other, and, not being disposed in regular lines, do not constitute that radiant appearance so common in ordinary trees, but are promiscuously dispersed through the cellular tissue. See fig. 28. Plate XVI. As this tissue itself is not, from the same causes, compressed either in the direction or to the extent before described, the smaller membranous partitions that divide the vascular radii from each

Common Textures. other are not produced; neither, for similar reasons, is there any distinct appearance of the larger partitions, that, at certain distances, intersect the diameter of other trees. The cellular tissue, therefore, in such plants, retains more of its primitive character, and appears everywhere to surround the vascular fasciculi, but nowhere to be so compressed as to form solid partitions between them. In some plants which possess this structure, as the Sugar-cane (fig. 26. Plate XVI.), the cells indeed retain their perfect forms, and even the fasciculi of vessels, though standing at considerable distances from each other, have towards the centre of the plant a symmetrical arrangement. This latter circumstance is observable in many other plants, which have even fewer vessels than the Sugar-cane; so that it is probable, that, in the first instance, it takes place in all; and that the irregular position of the vessels in the Palm and similar trees, particularly towards their circumference, proceeds from the peculiar modes of their growth, and are not a primary condition of their structure. This intermixture of the vessels and cells in the plants, now under consideration, extends from the circumference to the centre, so as to constitute their entire bulk, to the exclusion of bark and pith; unless we choose rather to say, that, in such plants, the medullary, ligneous, and cortical textures, are all blended together.

In Herbs. 117. In other examples, the vessels form a still smaller portion of the ligneous texture, consisting only of a few fasciculi which stand at considerable distances from each other, the intervening spaces being occupied by cellular tissue, which forms the chief bulk of the plant. See fig. 32. Plate XVI. Though few in number, the vessels, however, are symmetrically disposed, and, in the same species, preserve always the same position, the fasciculi being placed at the same relative distance from each other, and from the common centre of the pith. Sometimes, instead of a few solitary fasciculi, they consist of several ranges, forming an imperfect sort of concentric layers, and in such examples, the ligneous texture is commonly separated by distinct but irregular marks from the two other textures. In these plants, the cellular tissue preserves its characters, and exhibits no appearance of divergent rays.

Causes of its Varieties. 118. The three modes of arrangement above described, appear to constitute the chief varieties of structure in the ligneous texture; but in each variety, and through every stage by which they graduate into one another, the greatest diversity of forms prevails. Each species of plant has its peculiar *internal structure*, as well as its *external* form; and this seems to be in a great measure determined by the number of vessels that enter into its composition, and their peculiar mode of arrangement. If the vessels are few, the cellular tissue is large in proportion, and its characters are distinct and well preserved;—if they are numerous, and disposed in rays, the tissue is compressed in various directions, loses more or less completely its cellular character, and forms alike those divergent rays, or transverse partitions already so often noticed, and those thin membranous expansions, or *fasciæ*, which, both in the bark and wood, are seen sometimes to cover the vessels in a longitudinal direction.

119. The manner, too, or rather the place, in which the vessels are developed, in perennial plants, will greatly contribute to vary the appearance of the ligneous texture. In those trees, whose diameter is annually increased by the formation of new vessels around the cylinder of older wood, the new parts must necessarily present in their longitudinal section the appearance of annular layers superimposed on one another, and, in their transverse section, that of concentric circles; but in Palms and similar trees, where the developement of new parts seems to be accomplished in a different manner, their appearance, under similar sections, may be expected to be different. Common Textures.

120. In a longitudinal section of the Palm, says M. Desfontaines, we discover an assemblage of large ligneous fibres (that is, vascular fasciculi), solid, smooth, and flexible; and these are composed of others still smaller, which are firmly united together; they mostly run parallel to the axis of the trunk, from the base to the summit, without interruption; but some proceed obliquely, and cross the others at angles more or less sharp. See fig. 29. Plate XVI. In a transverse section of the same stem, continues the author, we remark neither concentric circles, nor transverse partitions; but the fasciculi of vessels placed without order by the side of each other, are enveloped by the cellular tissue, which fills up all the intervals: they sensibly approach each other, harden and diminish in size in proceeding from the centre to the circumference. See fig. 28. Plate XVI. So that the stem has much more strength and solidity near the surface, than in the interior, an organization quite distinct from that of ordinary trees. Structure of Palms.

121. The cause of this diversity of structure seems to be amply accounted for by the different modes in which the growth of these trees is accomplished. When the seed of a Palm is sown, the leaves, says M. Desfontaines, successively develope and augment in number for four or five years; the neck of the root augments in the same proportion; the bulbous part, formed by the reunion of the petioles of the leaves, increases insensibly; its solidity augments, and at length the stem rises above the earth with all the size it ever acquires. Its figure is cylindrical from the base to the summit, and if the diameter be measured at different epochs, it will be seen, as Kæmpfer had already remarked, not to increase. The Palm, therefore, is a regular column, whose summit is crowned with leaves, disposed above each other circularly; those which grow in spring shoot always from the top; the older ones, placed below, dry, and when they fall, leave circular impressions, which furrow the surface of the stem, and mark its years until it has ceased to grow. Their Growth.

122. If next we examine the interior, we discover, as M. Desfontaines thinks, the true reason why the stem rises in a column, and does not, like other trees, yearly augment in size. This was done by M. Daubenton, who states, that every leaf of the Date-palm, in proceeding from the bud, is formed by a prolongation of the vascular fasciculi and cellular tissue which exist in the trunk of the tree, as is apparent in the petiole of the recent leaves, and of the dried

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ones that adhere to the trunk. The elongation of the trunk is produced, therefore, by the leaves which annually proceed from it; and as the parts which form these leaves, spring from the centre, they always, as they shoot, force the older leaves outwards. Hence, therefore, as the augmentation of these trees originates at the centre, all the parts capable of displacement must be pushed outwards, just as the new layers of bark and wood, formed annually in ordinary trees, force outward the older layers of bark exterior to them.

Effects of the Growth on the Structure.

123. In these latter trees, continues M. Daubenton, the recession of the bark has no limits, so long as new parts continue to be formed beneath it; because the new cortical layers are flexible, and the older ones readily break and give way: but in the Palm, the substance of the trunk has more compactness as we approach the circumference, and, at a certain point of density, it no longer yields to the central force of the interior parts; so that, when this point is reached, no farther enlargement takes place; and hence, the Date-palm scarcely exceeds ten inches in diameter. It is for similar reasons that the trunk of the Date-palm is of the same size through its entire length; for, in proportion as the tree rises, the exterior parts of the trunk lose successively their flexibility, and when they have reached a certain degree of density, they no longer yield to the force from within; and as this is equally the case in all parts, the trunk is necessarily of the same size throughout. (*Mém. de l'Instit. Nat.* Tom. I. p. 482, &c.)

124. It is farther evident, that, in this mode of growth, no appearance of concentric circles, similar to those of ordinary trees, can have place; for, by the growth at the centre, the exterior vessels are continually displaced from their original positions, are more and more compressed as they are forced towards the circumference, and present, in their transverse section, that irregular distribution which they have been described to possess. Hence, the cylindrical figure and the absence of concentric layers are as necessary consequences of the mode of growth in these trees, as the presence of those layers and the conical figure are of the mode of growth in ordinary trees. The greater solidity of the parts at the circumference is clearly to be ascribed to the same cause; and even the want of regular transverse partitions must in part also have a similar origin, and be ascribed, perhaps, in part to the smaller number of vessels which these plants possess, as well as to their irregular distribution.

## Section III.

### *Of the Bark or Cortical Texture.*

The Bark.

125. This texture, in its component parts, resembles that of the wood, being made up, like it, of vessels and cellular tissue intimately connected with each other. Its structure, as a distinct texture, is best characterized in the bark of ordinary trees, as it is there separated, in a great measure, from the ligneous texture. As, in these plants, a new layer of vessels is annually made to the wood, so a similar, but much thinner layer, is yearly added to the bark, to which the name of *liber* has commonly been applied. These vessels are at first strait, and run parallel to the axis of the trunk; but, by the successive formation of new layers beneath them, they are gradually forced outward, become separated more and more from each other, and, touching in a few points only, exhibit at length a reticulated figure (See fig. 18. Plate XV.); the meshes of which yearly augment in size, from the greater space over which they are continually spread.

In Trees.

Is united to the Wood.

126. Between the vessels thus annually formed, a considerable portion of cellular tissue is interposed, which, in the young and succulent state of parts, contributes chiefly to the thickness of the bark. This tissue is variously compressed by the vessels, so as to form *transverse* partitions betwixt them, which, in the Vine, the Oak, and many other trees, as both Grew and Malpighi remarked, are seen to be continuous with those of the wood; and in this way the two textures are united together. In the expressive language of Grew, the bark, therefore, does not "merely surround the wood as a scabbard does a sword, or a glove the hand, but is truly continuous with it, as the skin of the body is with the flesh." In the Willow and other trees, when full of sap, the bark is so easily separated that it seems to have no connection with the wood; but this is supposed by Grew to arise merely from the extreme fineness and tenderness of the vessels that are annually formed in that part, and which, on that account, oppose no obstacle to the separation. (*Anat. of Plants*, p. 129.) It is probable, however, that the cellular tissue forms the only direct connection betwixt the cortical and ligneous textures, and that, if a vascular communication exist, it is only, as in all other cases, through the medium of that tissue.

Altered by Pressure.

127. Beside the transverse compression which the cellular tissue experiences from the vessels, it is compressed, in the opposite direction, by the formation of the new layers of bark and wood beneath the older bark. These, in the progress of their growth, exert an expansive force outwards, so that the cells of the tissue are made to assume an oblong or flattened form in the direction of the vessels of the trunk, or sometimes to form a thin *fascia* upon the vessels, in which the cellular character is nearly or entirely obliterated. It is by the continued exertion of this force, acting on the exterior and desiccated layers, that these latter ultimately crack; producing figures of different sizes, which have frequently the shape of rhombs, the fissures of which represent, according to Grew, the position and track of the vessels in their reticulations. (*Anat. of Plants*, p. 129.) The spaces or meshes formed by these reticulations, are always filled up by cellular tissue, which, in the opinion of Malpighi, originates from the vessels themselves.

Contains proper Juices.

128. Both in the vessels and cells of this texture, collections of the proper juices frequently occur; especially in plants in which these juices are of a viscid nature, and disposed to concrete; as was before remarked, when treating of the proper vessels. Similar collections of matter, originally existing in the bark, are likewise met with in every layer of wood, and even in the pith of certain trees. It is only in plants in which the proper juices are coloured, or

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disposed to concrete, that this intermixture of the cortical and ligneous textures has been traced through the whole substance of the tree; but it is probable, from the conjunction of the vessels of the bark and wood at the period of their formation, that it is common to other plants, the nature and properties of whose juices afford no clew to its detection.

The Bark in Herbs.

129. In most herbaceous plants, the cortical texture is not so clearly distinguished from that of the wood, since in them the greatest variety obtains both in regard to the number and relative position of the sap and proper vessels; and very frequently the cellular tissue is quite continuous, and of uniform appearance through the entire substance of the plant. In general, however, the sap-vessels occupy the inner place, and are surrounded by the proper vessels, disposed either in rings, or distinct fasciculi, more or fewer in number. Sometimes the sap-vessels seem to be placed exterior to the others, and hence it is difficult to discover the true place of the proper vessels in such plants, unless the nature of their juices conduct to it. From the position of the vessels, therefore, it is often difficult to define the boundaries of the cortical and ligneous textures, and for the reason already assigned, the cellular tissue rarely affords much assistance. According, however, to the number and disposition of the vessels, this tissue, even in these plants, suffers a certain degree of compression, so as to form thickened boundaries around the fasciculi, or sometimes large transverse partitions which communicate with those of the wood, in which, though the figure of the cells is more or less altered, the cellular character is usually preserved.

In Palms.

130. In other plants, the intermixture of proper vessels with those that carry sap, seems to be general through the whole plant; and consequently no distinction can be made between the ligneous and cortical textures. In such plants, the proper juices must be considered to exist in every part; and accordingly Malpighi, as we before remarked, points out a *vas proprium*, or proper vessel, as accompanying every fasciculus of vessels in different species of wheat. (*Anat. Plantar.* p. 24.) From the similarity of structure in Palms, and especially from their mode of growth, there can be little doubt that a similar intermixture of the two kinds of vessels prevails everywhere in them; and with respect to these plants, what has already been said of the construction of the ligneous texture, is equally applicable to that of the bark.

131. We have thus given a very brief and general view of the principal textures that enter into the construction of plants. and pointed out the more prominent diversities of character and appearance which they exhibit, as well in their simple as in their more complex forms; and as they exist either separately or variously intermingled together. Our descriptions have been confined entirely to the trunk or stem, but, with slight variation, they are applicable equally to the root and branch, in which a similar combination of the elementary organs obtains. In the root, however, they commonly exist in a more compressed and compacted form, so that the ligneous texture is seen chiefly to predominate, frequently to the entire exclusion of the pith; and often, in great part also, to that of the cellular portion of the bark. This is not however universal, especially in annual plants, some of which, as the carrot and others, particularly in a cultivated state, are distinguished by the very large portion of cellular tissue which enters into the construction of the cortical texture. Of the modifications of these several textures, as they exist in leaves and other organs, we shall have occasion to speak when we come to treat of them individually. We may now observe, that, how varied soever they may appear, when viewed only in their extreme results, yet all these variations seem to spring from a few original differences in character; which differences, modified by circumstances of subsequent duration and growth, produce, by gradations almost insensible, the manifold diversities of form and structure, which hereafter we shall attempt to describe.

In Roots and Branches.

In Leaves.

Mode of Connection of Vessels and Cells.

132. In our discussion of these several textures, we have noticed only in a general way, the direct means by which the vessels and cells that construct them are connected with each other; but, when treating of the sap-vessels of the absorbent vessels, and of the cellular tissue, we endeavoured to show, that an universal communication obtains between these elementary organs, and consequently inferred, that some mode of connection, by which it can be accomplished, must have place. Grew considered the vascular and cellular parts to be connected with each other, not only by the transverse partitions of cellular substance that intercept the vessels—but "*per minimas partes organicas;* that is to say, the parenchymous fibres are wrapped round about the vessels, or at least interwoven with them, and with every fibre of every vessel, as in very white ash or fir wood may be observed." (*Anat. of Plants*, p. 121.) These fibres, Grew elsewhere considers as vessels, and consequently must be regarded as maintaining, with Malpighi, a vascular connection between these organs. In a description of the young branches of Chesnut and Oak, Malpighi delineates minute filaments, springing on every side from the vessels of the wood, and continued into the adjacent cellular tissue (*Anat. Plantar.* p. 27.); but he does not state whether they are to be regarded as vessels or simple fibres. We have before shown, however, that he considered the cells to be everywhere furnished with minute ramifications derived from the perpendicular vessels; and, indeed, he held it probable, that the nutrient fluids, moving through the vessels, were, in in all parts, poured into the cells, and there undergoing a certain preparation, were afterwards mixed with more recent juices, and with them taken up and applied to the support of the young buds and leaves. (*Anat. Plantar.* p. 30.) This doctrine has since been held by Darwin and Knight, and it necessarily supposes a vascular connection between the vessels and the cells, by which the functions both of secretion and absorption can be performed. The microscopical observations of Leuwenhoeck, already noticed, supply farther evidence in support of this opinion.

Opinion of Grew;

of Malpighi;

133. In the hypothesis of Mirbel, both cells and vessels are considered as one and the same membrane. He rejects, therefore, the aid of all intermediate organs, as necessary to connect them together;

of Mirbel;

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and supposes a communication to be everywhere maintained between the vessels and cells, by the medium of pores in their sides. As, however, these pores are nowhere proved to have existence but in the imagination of the author, we may altogether reject their agency in maintaining a communication betwixt the vessels and cells of plants. In the opinion of M. Kieser, the conjunction of the cells with the vessels is extremely simple, the sides of the cells, says he, being contiguous to the sides of the vessels. (*Mém. sur l'Organisat. des Plantes*, p. 94.) But mere contiguity of parts does not amount to connection, much less does it afford any information concerning the actual communication that exists between these organs. In addition, therefore, to connection by cellular substance, it seems absolutely necessary to suppose also the existence of a vascular structure, which shall at once serve as a medium both of connection and communication.

of Kieser.

Resemblance of Vegetable to Animal Textures.

134. Before concluding this branch of the subject, we may observe that the structure of the cellular tissue, and its relation to the vascular system in plants, appears, in many points, to resemble that of the adipose cells, and their relation to the vascular system of animals. These cells are described as minute close cavities, possessing no apparent communication with each other; and within them adipose matter is alternately deposited and removed. Now, the deposition of this matter could only be accomplished by secreting vessels, which terminated in the cells, and its removal be effected by absorbents, which originated from them; and accordingly, both blood-vessels and absorbents are found to be present in this texture; but neither the secreting nor absorbing orifices have ever been actually observed. Within the cells of the cellular tissue of plants, the alternate deposition and removal of various matters are not less certain; and in the germinating seed, the matter that actually existed in the cells is found afterwards in the vessels. We are led, therefore, or rather we are driven, not only by the direct exclusion of all other alleged means of communication, but by a close analogy in the exercise of these animal and vegetable functions, to conclude, that secreting and absorbing vessels must be employed to deposit and remove the secreted matter from the cells of plants, in the same way as they are considered to effect similar depositions and removals of adipose matter from the cells of animals; and as this alternate function seems to go on in every part of the plant, capable of active vegetation, it may farther be inferred, that a vascular connection and communication exists between the vessels and cells in all parts of the vegetable system.

Irregular Movements of the Sap.

135. By means of this general communication between the vessels and the cells, we are enabled to assign satisfactory reasons for some puzzling phenomena, which have occurred in relation to the movements of the sap. It is by this alternate action of secretion and absorption, that, in young plants, we must suppose the cells of the pith, during the first year, to be filled with fluid; and to be rendered dry for the most part ever after. In like manner, the surface of the bark, in contact with the wood, appears, in some trees, as the Birch, to be rendered moist during the rise of the sap in spring; which led Dr Walker and others to suppose, that the sap rose in part betwixt the bark and the wood; an opinion not at all probable in itself, and certainly not supported by what is observed in most other trees. The fact, however, is easily explicable, on the supposition that the sap was transfused from the alburnous vessels of the wood, in the same manner as, at a later period, it is secreted in the same part, but in a different form, by the vessels of the bark, to form the new matter that is annually added to the tree.

Lateral Motion of Sap.

136. That the sap of plants was capable of moving in a *lateral* direction, was inferred by Malpighi from the fact that parts lived and grew, when the perpendicular vessels that supplied them with nutriment had been destroyed. (*Anat. Plantar.* p. 13.) The experiments of Hales afford more decisive evidence regarding this lateral movement of the sap. He cut two large gaps in the opposite sides of an Oak branch, at four inches distance from each other, carrying the incisions down to the pith: the branch nevertheless absorbed and perspired water, but only in half the quantity that another similar, but uncut, branch did. In branch of Cherry-tree, he made four similar cuts down to the pith, at four inches distance from each other, and opposed to the four points of the compass; the branch notwithstanding absorbed, in forty-eight hours, twenty-four ounces of water. (*Veg. Statics*, p. 128. 3d Edit.) And when similar incisions were made on branches, while still attached to the tree, their leaves continued green, nearly as long as those of other branches in a natural state; whence he justly inferred, that, at these gaps made in the branch, a lateral movement of the sap must have taken place. Experiments of a similar nature have been made, and like results obtained, by Mr Knight (*Phil. Trans.* 1808.); so that it seems clear, that, in certain circumstances, a lateral movement of the sap must have place.

How effected.

137. In what manner, then, must we suppose this movement to be accomplished? Grew supposed the cellular tissue, that stretches from the circumference to the centre of the plant, to be the instrument by which such a communication could be maintained; but the impermeability of this tissue to fluids opposes such an opinion. Malpighi thought the lateral communication to be made by an *anastomosis* of vessels; but in the vessels of plants no such mode of communication appears to exist. From the ascent of the sap in branches in which the vessels had been thus previously cut through, Mr Knight infers, that this fluid does not rise in the vessels at all, but is conveyed through the cellular tissue. This opinion necessarily implies the permeability of this tissue by fluids, which, as we have shown, is contradicted by direct experiment, as well as by microscopical observation. Since, therefore, this lateral movement of the sap cannot be accomplished, either by simple percolation through the cells or vessels, or by direct anastomosis of the vessels with one another, no other known means of effecting it remain, but those of alternate deposition and absorption by the vessels into and from the cells. And if, as we have seen, the sap-vessels of plants deposit coloured fluids in the cells which the capillary absorbents of parasitic plants are able to take up, there seems no reason for deny-

Common Textures. ing to the vascular productions, which have been supposed everywhere to spring from the perpendicular vessels, a like capacity of absorbing fluids from the adjacent cells. These fluids must, however, in all cases, have been deposited before they could be absorbed; and by the alternate exercise of these functions, there is no difficulty in conceiving how a lateral movement of the sap might be accomplished, in parts, where, by the incision of the vessels, a stop was necessarily put to its perpendicular ascent.

### Section IV.

*Of the Skin or Cuticular Texture, and its Appendages.*

#### Article I.

*Description and Structure of the Skin.*

[T]he Skin. 138. The skin, rind, cuticle, or epidermis, as it has been variously named, is the last of the common textures that remains to be described. It is the general envelope which invests all parts of the plant and all its productions, being equally common to the trunk and branches, the root, the leaves, the flowers, and the fruit; but in these different parts, and even in similar parts of different plants, it exhibits the greatest diversity of appearance, form, and texture.

[D]escrip[ti]on. 139. In herbaceous plants, and in the young shoots of those which are arborescent, it resembles a thin membrane, but is generally thicker on the stem than on the roots or leaves, and is of still more delicate texture where it is extended on the flowers. In some leaves, however, it is thick and dense, as is the case also in several fruits, and is thereby fitted to resist the effects of too rapid desiccation. On the upper surface of some leaves, on many fruits, and on roots, it is an entire membrane, destitute of any apertures or pores; but on many stems, on the under surfaces of leaves, and sometimes on the upper, it is frequently furnished with numerous pores, often visible to the naked eye, and with other luminous points of smaller dimensions, which Du Hamel also regards as apertures. It is readily separable from the bark in recent and succulent parts, or after maceration in water; and, in certain leaves, it is very completely separated by a species of caterpillar, named by Reaumur, the *miner*. It appears then to be a thin transparent membrane, often destitute of colour, and deriving, therefore, its appearance from the colour of the parts beneath; but both in leaves and flowers it is often itself coloured. It is frequently seen to extend in all its dimensions, in common with the parts it covers. Very often too, as will be noticed hereafter, its surface is covered with hairs, and sometimes small follicles or utricles are met with, which exercise a glandular function.

[In] Young [Tr]ees.

[In] Old [Tr]ees. 140. The characters above enumerated belong chiefly to the cuticle in its young and succulent state: In perennial plants, it commonly possesses others that are quite dissimilar. It is of a different colour not only on different trees, but on different parts of the same tree. It is white and shining on the trunk of the Birch, and browner on the branches; greyish on the Plum-tree; red and silvery on the Cherry; green on the young branches of the Peach, and ash-coloured on the larger branches. In these and many other instances, it does not, says Du Hamel, merely participate in the colour of the body it covers, but contributes itself to give colour to the exterior bark; for when it is stripped off, the substance below has frequently a different colour. (*Phys. des Arbres*, Tom. I. p. 10.) By the gradual enlargement of the trunk it is stretched and dried, and at length loses its vitality, and, as well as the bark beneath, is variously cracked and broken. Before this happens, however, it often undergoes considerable extension in all it dimensions, enlarging in breadth, and stretching longitudinally over the young shoots. This expanded state is particularly remarkable in certain fruits, in which, when they enlarge slowly, the cuticle is extended without rupture, to a very large size; but if the expansion be very rapid, as after considerable rains, the cuticle then gives way. In certain trees, the cuticle is more susceptible of expansion than in others; and in very vigorous trees, it breaks more slowly than in those whose growth is languishing, although these latter push forward more slowly than the former. (*Ibid.* p. 11.) In some vigorous trees of this description, it altogether resists rupture, and in this state the tree is often said to be hide-bound, or bark-bound.

141. In most instances, the cuticle, when taken from young branches, appears to consist of a single layer; but on the branches of many species, says Du Hamel, after one plate or layer has been removed, another may be seen beneath, which resembles the former in its texture, but is much thinner and more green and succulent. From the Birch-tree, he has removed more than six layers, very thin and very distinct from each other, and is of opinion that more might still be separated. Sometimes the original cuticle seems to be entirely thrown off, and the exterior covering is formed by a portion of the cellular tissue of the bark. Grew thinks that this substitution takes place annually, the older skin being cast off like the skin of an adder, by the generation of a new one beneath. (*Anat. of Plants*, p. 114.) Du Hamel describes also the existence of small leaflets or scales, which are continually detached from the cuticle of some trees; and these he considers to be as constantly replaced, by the formation of new ones beneath them. Composed of Layers.

142. Concerning the regeneration of the cuticle on parts from which it has been removed, Du Hamel observes, that when the wound is covered with waxed-cloth, a new cuticle is promptly formed without any separation of a portion of the bark beneath. When the exterior portion of the bark is removed with the skin, the inner part of it is equally capable of regenerating a cuticle; but if the wound be not protected from the air, a certain degree of exfoliation first occurs, and, under the decayed parts, a new skin forms. Even where the bark of a Cherry-tree was entirely removed from the trunk, he found that the wood was capable of regenerating a new bark and cuticle, if the parts were properly protected from the air. This cuticle did not originate from that which remained on the roots and branches; but was reproduced in isolated portions on different parts of the trunk; it continued, however, after the Is Regenerated.

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lapse of fifteen years, always different from that of the natural growth. In other instances, he adds, the cuticle does not seem to be regenerated at all. He remarks certain analogies to exist between the cuticle in some plants and in animals. Both, he adds, seem, in certain circumstances, capable of great extension; both are easily regenerated, and that in isolated portions, and not by continuity of organs, as is common in other instances; and both, lastly, are perpetually obliterated, and continually and imperceptibly renewed. (*Phys. des Arbres*, Tom. I. p. 11.)

Its Nature.

143. With respect to the nature of the cuticle, very different opinions have been advanced, and still continue to prevail. Are we to regard it as a peculiar organ, formed immediately by the proper exercise of the vegetative functions, or is it produced in a sort of secondary manner, by some changes induced on some previously constructed organ? Grew asserted it to be sometimes original, and in some instances produced out of the exterior layer of the cortical texture beneath it; and this view of its origin seems to be generally supported by the descriptive character which has been assigned to it. Its coexistence with the first traces of vegetable organization, its continued growth and expansion, and its subsequent regeneration, after removal, all seem to favour its primary and independent origin; and this view is also supported by investigations into its minute structure. Mirbel, however, and some other writers after Hill, have regarded it, in all cases, not as an original membrane, but formed by the exterior sides of the common tissue of the plant; and where there is no separation of these sides in the form of a membrane, such plants are held to be destitute of a cuticle. (*Exposit. de l'Organisat. Vég.* p. 103.) This may assimilate very well with the mechanical views that pervade all this author's speculations concerning vegetable organization; but will, we suspect, make few converts among those accustomed to contemplate the powers and properties of living textures.

Its Structure.

144. Another question relating to this organ is, Whether it must be considered a simple membrane of uniform structure, or a compound of two distinct parts, like the true skin and the cuticle in animals? Grew seems to have regarded it as a simple body, but constructed both of vessels and cells, the cells being continuous with those of the bark. (*Anat. of Plants*, p. 62.)

Opinion of Grew;

Such too seems to have been nearly the opinion of Malpighi, who describes it as constructed of horizontal ranges of cells, but often delineates reticulations of vessels as constituting a part of its structure. (*Anat. Plantar.* p. 2—19.)

of Malpighi;

In the Birch, the Plum, the Cherry-tree, and others, Du Hamel declares the component fibres of the cuticle to possess a direction transverse to that of the trunk; but this is not general. In the Birch-tree, the fibres seemed to be placed parallel to each other, and to be connected together by lateral fibres; but he could see nothing of the vesicular structure of Malpighi and Grew, and regards, therefore, the structure of this texture to be altogether fibrous. (*Phys. des Arbres*, Tom. I. p. 8 and 9.)

of Du Hamel;

M. Desfontaines, on the other hand, describes it as a membrane, resembling in appearance a thin plate of parchment, and perforated by imperceptible pores, which give issue to the insensible transpiration. Its structure he regards as unknown, but considers it capable of regeneration. (*Mém. de l'Instit. Nat.* Tom. I. p. 481.)

of Desfontaines;

of Kieser;

145. M. Kieser, who professes to have studied this texture with great attention, adopts nearly the opinion of Grew; pronouncing the cuticle to be constructed of a very fine cellular tissue, and of extremely minute vessels, which run through its whole extent. These vessels form an exceedingly delicate and subtile net-work, the meshes of which possess very different forms, and their vessels terminate at the orifice of a pore. His observations were made on the cuticle of leaves. On the inferior surface of the leaf of *Amaryllis formosissima*, (fig. 14. A. Plate XVIII.) magnified 260 times, these vascular meshes of the cuticle have an elongated hexagonal form; and four of their vessels proceed always to terminate at the orifice of the little oblong aperture or pore situated at their junction. In *Canna Indica*, the vessels of the meshes on the lower part of the leaf, which thus terminate in the pores, are said to originate from a fasciculus of the spiral vessels that ramify through the leaf; as is represented at *a'* in fig. 14. B. Plate XVIII.; and within the areas of the larger meshes, a still finer net-work of vessels is seen. On the inferior surface of the leaf of a species of Fern, the vessels of the cuticle, instead of forming meshes of different figures, exhibit the appearance of sinuous lines, which run in every direction through the cuticle. See fig. 15. Plate XVIII. which represents the central part of the little adjoining leaf, magnified 130 times. These sinuous vessels often join, and, after making a half circle, terminate by one extremity in the minute pores everywhere spread over the leaf, and by the other in the larger vascular fasciculi that ramify through it. At the letter *b'*, in this figure, the hexagonal cells that construct the parenchyme of the leaf, are distinctly visible through the vascular sinuosities of the cuticle. It was by the examination of this leaf that M. Kieser was first enabled to discover the origin and termination of the vessels that construct the cuticle; having in all his previous investigations examined the cuticle in its separated state, after it was detached from its connection with the other organs; but the researches made on this leaf rendered everything clear. (*Mém. sur l'Organisat. des Plantes*, p. 141-2.)

of Krocker and others.

146. The vascular net-work of the cuticle, thus described by M. Kieser and others, had been regarded as a deception by M. Krocker, who considered these reticulated figures as no part of the real structure of the cuticle, but merely as the sides of the subjacent cells; in which opinion, Sprengel, Link, Jurine, and Mirbel, concurred: but M. Kieser, in opposition to this opinion, maintains that, in the Fern and other leaves, the real cellular structure of the parenchyme is seen entire through the vascular reticulations of the cuticle, with the meshes of which the sides of the subjacent cells do not anywhere coincide. He observes that these cells are commonly much smaller than the vascular meshes which cover them; and that the vessels of these meshes may be traced, as before remarked, to the larger fasciculi that construct the leaf. In the Fern, the vascular structure of the cuti-

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cle is the same on both sides of the leaf, but the superior side does not possess pores.

Opinion of De Saussure:

147. A very different view of the structure of the cuticle was taken by the late celebrated M. De Saussure. He regarded it not as a simple, but a compound texture, consisting of a very delicate external pellicle or membrane, beneath which was placed a net-work of very fine vessels. The external membrane he describes as perforated by pores of unequal figure, between which he observed some opaque and tortuous filaments, disposed in a reticulated manner, each mesh being formed by six filaments, four of which terminated at each pore. To this arrangement of filaments, he gave the name of cortical network, and regarded it as quite distinct from the cuticle that covered it. The meshes of this net-work differ much in size and figure in different leaves; and, when minutely examined, they are often seen to form junctions, but never to cross each other; whence he was led to regard them as vessels derived from those of the expanded petiole, and thus constituting a very fine vascular net-work. A similar structure was observed in the petals of the flower. (*Encyclop. Méthod.* Tom. I. p. 67.)

of Decandolle.

148. M. Decandolle, to whose researches we before alluded when treating of the absorbent system, adopts a similar view of the compound nature of this texture. He describes it as consisting of a proper cuticle, and of a cortical net-work, the vessels of which terminate at oval pores, more or less elongated. Around these pores, the vessels (or fibres, as he calls them) form an oval ring, which is connected to the rest of the net-work, by two, three, or four radiating vessels, derived from the vessels of the petiole. These vessels of the petiole he considers to form, first, the larger vascular fasciculi; then, by their subdivision, the parenchyme of the leaf, and afterwards to construct the net-work that terminates at the pores. The form of the meshes of the vascular rings, and of the pores, is the same always in the same species, and on the same faces of the stem, the leaves, and the flowers. (*Mém. de l'Institut. Nat.* Tom. I. p. 351.)

149. Such are the very different opinions held by enlightened observers concerning this texture. Each professes to have given descriptions from accurate microscopical observation, and it would therefore be presumptuous, on mere reasoning alone, to decide on their respective merits. Granting to each party similar credit, as far as regards accuracy of observation, we confess that the latter opinion seems to us, on other grounds, best entitled to preference. In both views, the direct connection of the vascular system with the external pores of the leaf is admitted, which is perhaps the most important point in the inquiry; and the only difference is, whether these vessels shall be regarded as a constituent part of the cuticle itself, or as forming a fine vascular net-work, connected with, but still distinct from it.

### Article II.

#### *Of the Pores of the Skin.*

Description of Pores

150. The pores of the cuticle, called sometimes cortical or miliary glands, so often mentioned already, deserve a more detailed description. They were first noticed by Grew, who describes many orifices as existing on the leaves of different plants, which vary in size, number, shape, and position. In the white lily, they are of an oval shape, of a white colour, and each is surrounded by a slender border. When viewed through a good glass, they appear as if standing about $\frac{1}{6}$th or $\frac{1}{8}$th of an inch apart all over the leaf, but not arranged in any regular order. In the Pine also, they have an oval shape, but have no rising border; and are arranged in lines from one end of the leaf to the other. (*Anat. of Plants*, p. 153.) Hedwig considered the borders mentioned by Grew, as produced by a ring of one or more vessels which terminated in the pore. The number of pores he represents as exceedingly great. In the square of a line of the cuticle of a bulbous lily, he reckoned 577 pores.

by Grew:

by Decandolle.

151. The characters and position of these pores have been farther examined by M. Decandolle, on more than 600 plants. They occur most frequently on the leaves, occupying both surfaces in herbs, and in trees chiefly the inferior surface. Stems, in general, have no pores, except, as in the *Gramineæ*, where they are succulent, and have the character of leaves, or where the plant is altogether destitute of leaves, as the Cactus. On the prominent lines of the leaves and stems, no pores are to be seen, but only in the grooves or depressed surfaces. They are never observed on the root, not even on bulbous roots, where the scales of the bulb are true leaves. The small leaflets called *stipulæ* and *bracteæ*, sometimes have, and sometimes have not, pores. The *calices* of the flower, in general, have pores, but the petals have not. Pericarps exhibit great variety in regard to pores; fleshy fruits are generally destitute of them. The envelopes of the seed are destitute of pores, but they are found on all seminal leaves that rise above the ground. The lower tribes of vegetables, as the *fuci, musci, hepaticæ, fungi,* &c. are destitute of pores.

Influence of Air on the Pores.

152. The occurrence of pores in those plants where they are found, seems to be much influenced by external circumstances. They are never met with but on vegetables, and those parts of vegetables that are exposed to the air; and, therefore, the internal surfaces of many leaves that embrace the stem are without pores, though, on the external surfaces of the same leaves, they are abundant. No plant that is completely aquatic, nor any part of it that is habitually under water, is provided with these organs, but the parts which rise above the water, are furnished with them. In *Ranunculus aquaticus*, the leaves that are constantly under water, are destitute of pores, while those that float on the surface are provided with them, but only on their superior face. Even leaves, which do not naturally possess pores when under water, acquire them if they are made to grow in air; and land plants, on the contrary, when made to grow under water, may, by such treatment, be deprived of their pores. Thus, the leaf of green mint, when growing in air, possesses not fewer than 1800 pores on its lower surface; but if kept for a month under water, its leaves fall, and the new ones that succeed are destitute of pores,

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Of Light on Pores.

153. Light seems to be necessary also to the production of pores, for etiolated plants do not possess them. When grown by the light of lamps, the leaves possess a few pores; and in all cases, the parts secluded from light and air are destitute of these organs, but acquire them if they are duly exposed. These pores, M. Decandolle, as we had before occasion to remark, considers to perform alternately the functions both of transpiration and absorption. (*Mém. de l'Instit. Nat.* Tom. I. p. 351.)

Researches of Rudolphi.

154. This general account of the pores of plants is confirmed by the researches of M. Rudolphi. In most herbaceous plants, he found the pores to occupy both sides of the leaf, but in trees, only the inferior surface. They were not often met with on the parts of the flowers, or on fruits; they were never seen on roots, nor on the trunks of trees; nor ever on aquatic plants, except on such parts as were raised above the water. The lower tribes of vegetables seemed to be universally destitute of them; the leaves also of those plants that were covered thickly with hairs on both sides had no pores. The form of the pores was commonly oval or elliptical, but in a few instances square or rhomboidal. In size they very much varied in different plants, but in the same plant the size was uniform. The largest pores were seen on the leaf of the white lily; the smallest on that of the French bean. (*Kieser's Mém. sur l'Organisat. des Plantes*, p. 144.)

Pores not essential to the Cuticle.

155. From these accounts of the occurrence of pores, and of the conditions necessary to their production, they cannot be considered as an essential, or indeed a primary character of the cuticle; but as owing their existence to the more perfect exercise of the vegetable powers. Hence the probability that they are caused by innumerable vascular productions from the larger fasciculi of vessels, which gradually penetrate the cuticle, and thus open a way for the discharge of their fluids, as the researches of De Saussure and Kieser seem to prove. That the exclusion of air and light should prevent the formation of pores in the cuticle, is nothing more than we see daily on a larger scale, with regard to branches themselves; for trees that grow very much crowded together, seldom produce branches from their sides; and if herbaceous plants be made to grow entirely secluded from light, they run altogether into stalk, and produce no buds or leaves from their sides.

### Article III.

### *Of Hairs.*

Description and varieties of Hairs:

156. From the surface of the cuticle, in many parts of herbaceous plants, and in the succulent parts of arborescent ones, hairs (*pili*) are seen to spring. They possess very different forms, and vary likewise greatly in texture. In a strict sense, they may be defined small filaments possessing considerable stiffness, which project from the surface, and stand out pretty erect. When they are very numerous, a little soft, and less erect, they take the name of *villi;* when still softer and less numerous, they are termed down *(pubes)*. Sometimes this down is composed of long hairs nearly resembling wool; at other times it approaches more to the character of cotton. When the hairs are stiff and ranged along the edge of a surface, like the lashes of the eye, they are named *cilia;* and if, with these characters, they are produced to a greater length, as in the beard or awn of wheat, they acquire the name of *barba* or *arista*. Sometimes they resemble the bristles of the hog, and are then called *setæ*. Many other varieties are enumerated by botanists, who farther distinguish them by various names, according as they terminate in a single point, or are hooked, or forked, or branched, or feathered, &c. In some instances, instead of appearing like one continuous substance, they are composed of many joints, or are said to be articulated. In figures 16. and 17. Plate XVIII. we have copied from Du Hamel a few of the varieties, both of single and jointed hairs; but the forms they exhibit are so numerous and diversified, that we must refer to the writers on botany for minuter information. In some examples, the point of the hair is terminated by a small rounded globulet, and sometimes by a fine filament that seems to proceed out of the hair.

their Position:

157. According to M. Decandolle, these several varieties of hairs appear generally on those parts of the stem and leaves that are destitute of pores; that is, on the prominent lines formed by the fasciculi of vessels, and which have been absurdly called the *nerves* of the leaves. They appear also on the edges of leaves, whose pores are never seen, so that, in position, the hairs and pores always differ. *(Mém. de l'Institut. Nat.* Tom. I.) On the petals of flowers, as well as on leaves, various capillary productions also occur, which frequently contribute much to their richness and beauty.

Structure.

158. With regard to the structure of these minute bodies, little that is satisfactory can be said. They seem to originate either directly from the cuticle, or from the cortical texture beneath it; but not often from the ligneous texture, except in those instances where they are very long and rigid, as in the awns of wheat. Du Hamel observes, that almost all of them are implanted on small bodies, similar to the bulbs which give origin to the hairs of animals. *(Phys. des Arbres*, Tom. I. p. 183.) They commonly resemble simple filaments, but often appear like elongated cells threaded on one another, and, instead of terminating in a sharp point, end in a small papilla or utricle, which yields, in many instances, a viscid or oily matter, or sometimes a coloured liquor, which has led many to regard them as exercising a glandular function. One species of these supposed glandular organs has been more particularly studied, and their fluid analysed by M. Deyeux, who gives the following account of it.

Hairs of Chick-Pea.

159. Soon after the seeds of the chick-pea (*Cicer arietinum*) are sown, its first leaves are seen to be covered with hairs, at the extremity of each of which is a transparent globule, about the size of a small pin head, consisting of a fluid matter. It abounds most in mid-day, when the air is warm and dry, and is scarcely perceptible at night, or when the air is cold and moist; after rain, indeed, it does not again appear for two or three days. When these fluid globules were removed, in a dry day, by blotting paper, they soon again reappeared; they were acid to the taste,

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reddened litmus paper, and caused an effervescence in carbonate of potass, when brought in contact with it. He regarded them as composed of oxalic acid, the properties of which they precisely resembled. (*Mém. de l'Instit. Nat.* Tom. I. p. 157.)

Hairs not Glandular.

160. These acid globules, and perhaps the other viscid, and oleaginous, or resinous substances furnished by hairs, are not, properly speaking, glandular secretions; but peculiar fluids, which, after their separation from the fluids of the leaf, experience certain changes from the agency of heat and light, during their passage through these delicate organs. There does not, therefore, seem any good reason for considering such bodies as glands. Many have considered these hairs, as the organs by which transpiration is carried on, and others, as those by which dews and fluids are absorbed—offices for which their structure seems but little fitted; and the transpiring and absorbing powers of leaves, are in proportion to the number of their pores, and not of their hairs. In many instances, they are obviously designed for protection against cold and moisture; but this is not the place to consider their uses, farther than is necessary to assist in establishing their anatomical character.

### Article IV.

### *Of Prickles.*

Definition:

161. It is not easy to discriminate between some of the harder species of hairs, described in the former article, and those to which the appellation of prickles (*aculei*) has been assigned. They are defined by Du Hamel to be excrescences, often hard, and always terminated by a sharp point, which are developed with the other productions of plants, but are not enclosed in particular buds; so that they may, for the most part, be regarded as hard and solid hairs.

Position:

162. They spring equally from the stem, the branches, the petioles of the leaves, and also from the leaves themselves in various plants; and in the Chesnut and some others, they are seen to cover the fruit. They are frequently strait, but in the Rose and many others are curved at the point, as in fig. 18. Plate XVIII.; and, according to Malpighi, possess sometimes in this plant a little head, which yields a viscid fluid.

Structure.

163. Regarding their structure, Grew remarked, that they were connected only with the skin or the bark, and he therefore named them *cortical*, to distinguish them from thorns, properly so called, such as those of the Hawthorn, which spring from the wood, and which he denominates *ligneous*. These latter, he adds, always ascend, while the cortical thorns commonly point downwards. (*Anat. of Plants*, p. 33.) In proof of their origin from the bark, Du Hamel remarks, that, if, after maceration in boiling water, the bark of such plants be stripped off, all the prickles come away with it, and leave not the smallest impression on the wood, nor even on the more interior layers of the bark itself. When a section also is made of the branch and prickle, as in fig. 18. Plate XVIII. the wood $y$ and the pith $z$ are both seen to have no connection with the prickle, but the inner layer of the bark $x$ is interposed between the base of the prickle and the wood. The prickle does not, however, spring from the skin, for it is formed of many layers like the bark. As the parts become more solid, it is less freely supplied with juice, and therefore hardens and turns brown. (*Phys. des Arbres*, Tom. I. p. 188.)

Prickle of the Nettle.

164. In the Nettle (*Urtica dioica*), Malpighi states, that, beside the common prickles on the leaves, there are among them others of a different description. They possess more of a ligneous character, are hollow internally, and contain a juice, which, when it gains admission beneath the skin, excites itching and tumour. (*Anat. Plantar.* p. 137.) Dr Hooke had previously given a much more minute account of the sting of this plant. Almost every part of it, says he, is covered with prickles, like sharp needles. Each prickle consists of two parts, very different in shape and quality from one another; one is shaped much like a round bodkin, is very hard and stiff, exceedingly transparent and clear, and hollow from top to bottom. When this bodkin is thrust into the skin, it does not at all bend; but a certain liquor is then seen to move up and down in it, rising towards the top, when the point is pressed down on the base. This base is formed by a little bag, is more pliable than the bodkin part, and within it is a cellular structure which contains a thin transparent liquor; see fig. 19. Plate XVIII.; it is this liquor that rises in the tube, and, being deposited beneath the skin after it is punctured, excites the irritation that succeeds. (*Micrographia*, p. 142.)

From the analogy in structure between thorns, properly so called, and branches, we shall defer their consideration until we come to treat of the structure of the branch.

## Section V.

### *Of the Glands of Vegetables.*

Ambiguity of the term Gland,

165. Perhaps, in the whole science of Anatomy, there is no word that has been employed with such latitude of signification, and is, therefore, exposed to so much ambiguity, as the term *gland*. In animal anatomy it was doubtless used at first to denominate certain organs from the external resemblance which they bore to certain fruits or seeds; and in that sense it is still employed on several occasions. Afterwards, it was understood to signify not so much the external form as the internal organization, and was considered to express a certain structure, by which alone the function of secretion could be exercised; but it is well observed by Dr Thomson, in his valuable work on Inflammation, that "the definition of a secreting glandular part must be taken from its function, and not from its structure; for nothing can be more various than the internal structure of those organs that are denominated glandular secreting organs; they consist sometimes of convoluted vessels, sometimes of follicles or small hollow bags, and sometimes of transparent membranes, in which neither convoluted vessels, nor mucous follicles, can be perceived." (*Lectures on Inflammation*, p. 318.) Besides these more simple structures, it is well known that most of the internal *viscera* are likewise denominated glands, though differing, in all their characters, from those just mentioned.

in Animal Anatomy.

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In Vegetable Anatomy.

166. The ambiguity which thus prevails in animal anatomy, in relation to the use of the term gland, has been increased tenfold in the applications that have been made of it to the organs of vegetables. It is justly observed by M. Decandolle, in reference to this subject, that the numerous approximations in structure between vegetables and animals have often promoted our researches into the former, but have sometimes led physiologists astray, and introduced into the language of botany many inexact expressions. In animal anatomy, the term gland is understood to express some organ that exercises a secretory function; but, in vegetable anatomy, this term has often been applied to bodies that are not known to be real secretory organs. Thus, the cells of the cellular tissue, which frequently contain resinous or oily matter, have been sometimes named *cellular glands;* the little globulets or utricles at the extremities of the hairs on the edges of leaves, *utricular glands;* the small organs formed by the pores on the leaf, *cortical* or miliary *glands;* certain fleshy tubercles on the leaves, *urceolar glands;* and the little scales that cover the fructification in ferns, *scaliform glands.* The *nectarium* of the flower commonly contains a sweet juice, and is, therefore, deemed a gland; but Linnæus, with his usual disregard both of the structure and function of organs, considers as a nectary, not only the body which may secrete, but any other that may serve as a receptacle of the secretion; and, indeed, is said to comprehend under this term all those bodies which have no resemblance to the other parts of the flower, in whatever variety of form they may appear, or whatever purpose they may serve. (*Willdenow's Prin. of Botany*, p. 87.) In some other instances, the term gland has been used not to express the secreting organ itself, nor even the receptacle of the secretion, but the solid excreted matter on the surface of certain leaves; and others consider hairs, and every other protuberance that projects from the surface, and contains a fluid different from the common sap, as entitled to the distinctive appellation of gland.

Difficulty in defining Glands.

167. Amid such diversity of opinion concerning the structure, position, and function of these minute organs, and such vagueness in the methods employed to characterize them, it is extremely difficult to define their true nature, or declare the principle on which this definition should proceed. The mere existence of a fluid, distinct from the common sap in any organ, cannot be considered as bestowing on it the title of gland, otherwise the greater portion of some plants would come to be regarded as glandular; those varieties of structure, which exercise no secretory function, may also be excluded from the list of glands; and so likewise the hairs of plants, though containing peculiar fluids, may be excluded, since these peculiarities appear to arise frequently from circumstances foreign to the action of the organ itself, and even if they do not, some specific variation of the general name they bear is preferable to the employment of so ambiguous a word as gland. But where any organ is distinct from the common textures of the vegetable, and, by the peculiarity of its structure, is fitted to produce those changes on the vegetable fluids which we name secretion, it may be deemed a secreting organ. This secretory function, however, may sometimes be exercised, as in animal bodies, by membranous surfaces, and sometimes by small isolated bodies, to which, perhaps, may properly belong the denomination of glands.

Modes of naming them:

168. But, even though this method of defining glands were adopted, it still is a matter of no small difficulty to distinguish their species by appropriate appellations. In animal anatomy, no settled rule obtains; but the name of the gland is assigned from some accidental circumstance of situation, figure, use, &c. In vegetable anatomy, the botanist, regarding glands only as aiding the discrimination of species, refers commonly to their situation, and speaks of foliaceous, stipular, or petiolar glands, according as they happen to be seated on the leaves, the stipulæ, or the petioles. The anatomist imposes names according to their forms, as they chance most to resemble a globule, an utricle, or some other figure; and the physiologist is chiefly directed by ideas which indicate their functions, distinguishing them into mucous, oily, resinous, or nectariferous glands, according to the nature of the fluid they furnish. Of these different modes, that which proceeds on the apparent form, where it can be discovered, seems the most precise; but as this cannot always be accomplished, the situation of the organ, or the nature of the secreted fluid, must occasionally be had recourse to.

are placed externally.

169. Of these bodies, it is to be remarked that they differ in one respect from most of the corresponding organs in animals, almost all of them being seated on the *external parts* of the plant, like several of the more simple glandular bodies in animals. This arises from the greater simplicity of vegetable organization, particularly as it regards the absorbent system, the mode of growth, and the permanence of the organs produced; whence it happens that the living parts of aged perennial plants are situated only at, or near the surface; and it is only in such parts that active secretory functions can have place. Hence it is on succulent stems, on leaves, flowers, and fruits, during the active state of vegetation, that the glandular functions of vegetables must be exercised, and which parts, therefore, are the appropriate seat of glands.

Species of Glands,

170. In some leaves a secretory function extends over a great part of the surface, as in some species of *Cistus*, of Sugar-maple, of Larch, and others, enumerated by Du Hamel, on which various collections of saccharine, gummy, and resinous matter are found. (*Phys. des Arbres*, Tom. I. p. 183.) On the leaves of Sage, Hooke mentions the occurrence of an infinite number of round balls resembling pearls, and which, says he, are nothing but a gummy exudation. (*Micrographia*, p. 142.) M. Gnettard has described not fewer than seven species of glandular bodies on the leaves of different plants, to which he assigned names, chiefly from the appearance of their form; these are the *miliary*, the *vesicular*, the *squamous*, the *globular*, the *lenticular*, the *utricular*, and the *urceolar* glands. Of these reputed species, those called miliary are no longer held to be glands, but cuticular pores; and the squamous species is found

by Gnettard:

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to be identical with the thin scale that covers the fructification of ferns. Others add to this list the organ called nectary; but the very vague notions entertained of its nature and use altogether preclude the possibility of assigning to it any precise anatomical character.

by others.

171. Other writers have proposed to reduce all the bodies called glands to two classes, the *cellular* and the *vascular*, according as they conceive them to be formed of cellular tissue simply, or of this tissue and vessels combined. But such an arrangement would lead us, in some instances, to confound the mere receptacles of secreted fluids with the organs that secrete them; would bestow a secretory function on organs, considered by these writers to be *non-vascular;* and convert the entire cellular tissue of the plant into a simple glandular body. The glands of plants may indeed possess the form and size of cells; but they are not, like cells, close cavities; they resemble more the follicles and mucous glands of the animal system, and, from the nature of their function, must always be regarded as vascular.

Of organs so minute, and so very imperfectly known and characterized, nothing can be attempted in the way of anatomical demonstration. This, however, is the less to be regretted, as the glandular system in plants appears, in general, to be of much less consequence in the vegetable, than it is in the animal economy.

# PART II.

## THE ANATOMY OF THE INDIVIDUAL MEMBERS AND ORGANS OF VEGETABLES.

Preliminary Observations.

172. In the preceding Part, we have described, in general, the nature of the elementary organs and common textures that compose the entire plant; and we come now to the second division of our subject; viz. the description of individual members and organs. Following the method of Grew, we shall first exhibit the anatomy of the seed, and the changes of form and structure displayed in its evolution. We shall next treat of the mature plant, and exhibit views of the more remarkable varieties of structure observed in its several members, as the trunk, the branch, and the root. The organs that originate from these members, as buds, leaves, flowers, and fruits, will then be duly noticed; and we shall terminate our descriptions by a brief exhibition of the formation and structure of the vegetable *ovum* in its progress towards the state of the perfect seed.

The limits within which, in a work like the present, we are necessarily circumscribed, will render our view of these individual structures, when compared with the immense variety that obtains in nature, exceedingly imperfect; but our purpose will be accomplished, if we succeed in exhibiting a correct and tolerably comprehensive outline of the great features of vegetable organization, as they are displayed in the individual parts and organs of the more perfect plants.

### CHAP. I.

#### THE ANATOMY OF SEEDS.

#### SECTION I.

#### *Of the Structure of Seeds in general.*

#### ARTICLE I.

#### *Of the External Characters and Component Parts of Seeds.*

The Seed:

173. The seed or egg of vegetables *(semen vel ovum)* is formed at the base of the pistil of the flower, in an organ called the ovary *(ovarium)*, hereafter to be described. To this organ it is attached by a small stalk, called the umbilical cord *(funiculus umbilicalis);* but sometimes, it is said, this cord, probably from its extreme tenuity, or implication with other organs, cannot be discovered. When the seed has attained to maturity, the umbilical cord dries up and breaks; and the ovary, in different plants, opens in various ways, to permit the escape of the seed.

its attachment to the Ovary.

174. The seeds of different plants exhibit the greatest diversity in number, size, and figure. Sometimes they are few; in other instances very numerous. In one plant of white Poppy, Grew reckoned 32,000 seeds; and on the spike of a species of *typha*, he numbered 40,176 seeds; so that, upon the three spikes which one stalk of this plant bears, there are every year produced more than 120,000 seeds. (*Anat. of Plants*, p. 198.)

Numbers of Seeds:

175. In figure, the varieties in seeds are so numerous as to baffle description; and, with respect to size, many are so minute as not to be visible to the naked eye, and others so large as to reach several pounds in weight. The minute corpuscles, which are held to represent the seeds of certain cryptogamous plants, have received particular names from different writers; but mere difference in size seems not, in an anatomical view, to afford any just reason for such distinctions.

their Size and Figure.

176. The part at which the seed has separated from the ovary, is indicated by a small mark or scar, called by Malpighi *fenestra;* by Linnæus *hilum;* and by Gærtner *umbilicus.* In some seeds, this scar is of considerable extent, and is the only mark that is visible; in other instances, there seems to be present a *foramen* in addition to the scar. All seeds, says Grew, have their outer coats open, either by a particular aperture, as in the bean C. fig. 21. (*a*) Plate XV., or by the breaking off of the cord, or by the entrance of the cord into the substance of the seed, as in those which have a shelly or stony covering. In the Bean, this aper-

Umbilicus of the Seed.

Of the Seed. ture is placed on the side; in the Chesnut, on the top; in the Gourd, at the bottom; and in each case, the point of the radicle is opposed to the aperture, and first pushes forth through it. (*Anat. of Plants*, Book I.) In many seeds, however, the radicle is not thus opposed to the umbilicus; but, according to Gærtner, is variously placed with regard to it; and in the seeds of the Apple and Pear, Malpighi considers no proper umbilical aperture to exist, but only an *hiatus* to be formed by the relaxation of the tunics, through which the radicle makes it way. (*Anat. Plantar.* p. 9.)

Varieties in its Form. 177. There can be no doubt, that, in every case, a connection subsisted between the seed and the ovary, during the formation of the seed; but this, in different examples, may have much varied. In all cases, an umbilical cord must have existed, and appears, in many examples, from inspection of mature seeds, to have been the only visible medium of connection. In the Bean, however, beside the umbilical cord, there are marks of a connection also between the coats of the seed and those of the ovary that contained it; so that the scar or cicatrix, in that and similar cases, is distinct from the umbilical aperture. The scar is the mark left by the separation of the tunics continued from the ovary; the foramen is the aperture produced by the separation of the umbilical cord. It will be afterwards stated, that the outer coat of the seed appears always to have originated from the inner coat of the ovary; so that it forms a sheath about the umbilical cord. If, therefore, as in the Bean, these coats are thick, and the umbilical cord short, then traces of the separation, both of the coats and of the cord, will remain on the seed; if, on the other hand, the coats are thin, and the cord more elongated, this latter will be closely invested by the former, and the umbilical scar will present the appearance only of a simple aperture, as is common to many seeds.

Opinion of M. Turpin. 178. A late writer, M. Turpin, regards the umbilical scar as consisting of three parts, viz. the proper cicatrix itself, in the centre of which he describes an aperture through which the nutrient vessels passed to the embryo, and near to it another smaller aperture, through which he believes the spermatic vessels to have passed. The former he calls the *omphalode*, the latter the *micropyle*; and declares, that he observed it in more than 1200 seeds. (*An. du Mus. d'Hist. Nat.* Tom. VII. p. 199.) Aware, however, of the fallacy of microscopical observation employed on such minute objects, we shall suspend our belief in the existence of this structure, until it receive confirmation from some other observer. As yet, we believe, no one has been able to share with M. Turpin the benefit of this discovery.

Regions of the Seed. 179. From the situation of the umbilicus, the several parts or regions of the seed have been defined. They are six in number. The part where the umbilicus itself is placed, is termed the *basis*, and the point at the opposite extremity, the *vertex* of the seed; the upper or back part is named the *dorsum* or back; and the part opposite to it the *venter* or belly; while the two lateral portions are called the sides (*latera*). The point where the umbilical cord is inserted into the inner coat has been named the *internal umbilicus*. This point usually coincides with that of the external, but, from a change in the relative position of the parts during their formation, this coincidence is not always to be observed. (*Gærtner de Fructib. et Seminib. Plantar.* Vol. I.)

Internal Umbilicus.

Coats of the Seed. 180. When examined in its mature state, the seed is found to be composed of certain coats or tunics, which enclose a kernel or *nucleus*, that also consists of several distinct parts. At an early period of growth, while the parts are still green and succulent, two coats are easily distinguished; as in the transverse section of the bean, D. fig. 21. Plate XV.; in which the inner coat appears much thicker than the outer, and the radicle ($b$) is seen rising through it.

Its Nucleus, When these coats are stripped off, the other parts, which form the *nucleus*, are brought into view. They consist, in the Bean and most other seeds, of two distinct parts, the lobes or cotyledons, as they have been called, and the radicle and plume. These several parts can be seen only by separating the two lobes from each other, as is done in fig. 22., where the letters ($cc$) denote the cotyledons, ($d$) the radicle, and ($e$) the plume. Such seeds as have thus two cotyledons are named *dicotyledonous*.

in Dicotyledons.

181. In many seeds, however, the part called cotyledon is single, and bears but a small proportion to the entire bulk of the seed. An example of this kind is presented in fig. 23. which represents a section of the seed of *Canna Indica*. The nucleus enclosed in its two tunics, forms, as before, the chief bulk of the seed, and in its centre appears an oblong body ($f$), which is the cotyledon, at the base of which the minute radicle and plume ($g$) may be discovered. The little oblong body below, represents the cotyledon alone. Seeds, which have thus but one cotyledon, are named MONOCOTYLEDONS; and to this division the seeds of wheat, barley, and all the grasses belong.

In Monocotyledons.

Acotyledons. 182. Some botanists have alleged, that several orders of the lower tribes of plants are entirely destitute of a cotyledon, and have given to such the title of ACOTYLEDONS. This title was formerly considered to apply to all cryptogamic plants; but the researches of the elder Jussieu and of Hedwig, are said to have proved it to be inapplicable to Ferns and Mosses; and the seeds of the *Algæ* and *Fungi* have not yet been discovered. Others assert, that some seeds have more than two cotyledons, and such seeds they have denominated POLYCOTYLEDONS; but others again choose to consider these appearances not as distinct cotyledons, but only as deep fissures, or divisions in two primary lobes—and hence conclude, that all seeds may be classed under the two divisions of mono and di-cotyledons. We are not competent to decide on the merits of these opposite opinions; but shall only observe, that they seem to be governed as much, at least, by preconceived views of system, as by unprejudiced observations of nature.

Polycotyledons.

ARTICLE II.

*Description and Structure of the Coats of Seeds.*

183. Having given this general view of the several parts that compose the seed, we proceed now to a more particular description of their structure; and,

Of the Seed.

as the tunics come first into view, we shall begin with them. These tunics, in some seeds, are two; in others, three, in number. By Grew, they were named coats or covers; by Malpighi, *secundinæ;* and by Gærtner, *testa* and *membrana interna.* We shall speak of them in the familiar terms of the outer, the inner, and the middle coats, or tunics.

Number of Tunics.

Outer Coat.

184. The outer coat or *testa* of Gærtner, is described as a constant and essential part of the seed. It existed before the period of fœcundation, and is sometimes the only apparent covering possessed by the mature seed. Some seeds have indeed been considered to possess no tunic whatever; and have therefore, says Gærtner, been named *acocca;* but in such seeds there existed a coat before they arrived at maturity, and its apparent absence has been inferred from its extreme thinness, or its condensation with the sides of the surrounding ovary. (*De Fructib. Plantar.* Vol. I. p. 132.) A distinguished botanist, however, Mr Brown, is said to have lately discovered two examples of seeds absolutely destitute of a covering, from their first appearance to their state of maturity. (*Thomson's Annals of Philosophy,* Vol. I. p. 310.)

Its Structure.

185. In different seeds, this tunic possesses a very different structure, being in some thin and membranous; in others of a spongy or fleshy nature; and in others, again, it approaches to the consistence of leather or bone. But how various soever in this respect, it is always an entire tunic, and has no aperture but that of the umbilical foramen. Its colour is usually deeper than that of the other parts of the seed, and in this particular it presents every possible variety. It has rarely any connection with the nucleus, except in some monocotyledons. (*Gærtner.* Vol. I. cap. 9.) With regard to its origin, Malpighi describes it, in its earliest state in the Almond, as derived from the ovary itself, being composed of reticulated vessels, which spring from the surrounding organ. In other instances, it is thicker, and is distinctly seen to be cellular, as well as vascular; and in the Bean and Pea, little tubes are said by Malpighi to originate from the cells, and terminate by open mouths on the surface. (*Anat. Plantar.* p. 9.)

Its Origin.

Pellicula.

186. Both Malpighi and Grew discovered, in some instances, a very thin membrane to cover this outer coat, which, according to Gærtner, may be found in most seeds, if the parts be scrupulously examined. Its structure is sometimes membranous, often downy, and sometimes mucilaginous; it possesses occasionally considerable thickness, and at other times is a mere pellicle; and thence has been named *pellicula.* It covers the whole seed, and does not ever separate spontaneously from it. (*Gærtner de Fructib.* &c. Vol. I. cap. 9.)

Arillus.

187. Besides this pellicle, another fine tunic named *arillus,* is sometimes observed on the surface of the seed, as in the seed of Euphorbia. It originates from the umbilical cord at the base, and extends more or less completely over the body of the seed. Its structure is very various, being sometimes soft and pulpy; at others, thin and membranous; and in others, forming a husky covering. It forms, in some instances, only a loose and partial covering; and in others, it invests the seed so closely and completely, that it can scarcely be distinguished from the outer coat itself. Both in figure and colour it often varies greatly; but, like the pellicle before described, it is regarded rather as an accessory, than a necessary integument.

Appendages of Outer Coat.

188. To the exterior coat of the seed, various appendages are sometimes attached, as down, wings, spines, hooks, all designed either as a defence to seeds, or to facilitate their dispersion. They are distinguished and described by the botanist; but are, in general, of too fine a texture to be made the subject of anatomical demonstration.

Inner Coat.

189. The inner tunic (*membrana interna* of Gærtner) is a common, but not constant part of the mature seed. It appears sometimes to be wanting, when in reality it is present. During the formation of the seed, it is frequently so extenuated, or coalesces so completely with the outer coat, that it cannot be properly distinguished. In its earlier state, it is represented by Grew as a very spongy and succulent body, and as thick and bulky as one of the lobes itself; but it dries and shrinks up as the seed approaches maturity, so that it is sometimes scarcely discernible. (*Anat. of Plants,* p. 47.) In the seeds of most plants, it closély invests the nucleus, but is easily separable from the outer tunic. In those of the *Gramineæ,* where the bulk of the seed consists almost entirely of inorganized matter, no separation of this tunic from the contained parts occurs; but its inner surface is formed into a cellular tissue, in the cells of which the nutrient matter is lodged. In other instances, the inner surface is prolonged into processes, which penetrate into the nucleus, and intersect it in various directions.

Its Origin and Structure.

190. This inner tunic does not, like the former, exist before fœcundation, but is formed subsequently to it. It is composed of vessels and cellular tissue. The cells are commonly larger than those of the outer coat. It has no aperture, says Gærtner, not even an umbilical one; but resembles a shut sac, over whose external surface the umbilical vessels creep, and open, in an insensible manner, within its cavity. (*De Fructib.* &c. cap. 9.) The distribution of the vessels throughout the whole of this coat Grew compares to that in the leaf.

Inmost or third Coat.

191. Beneath this inner tunic, Grew describes another fine membrane, which immediately invests the lobes or cotyledons of the seed. In the Bean, it is exquisitely thin, and so firmly continuous with the lobes, that some dexterity is required to accomplish its separation. It is spread not only over the convex surface of the lobes, but also over the inner or flat surfaces, where they are contiguous, extending likewise over the radicle and plume, and so over the whole nucleus of the seed. It does not, like the other tunics, cease to grow in germination, but is augmented and grows with the organic parts. (*Anat. of Plants,* B. I. ch. 1.) This tunic may be regarded either as a covering to the nucleus, or as an actual portion of it, as Gærtner, who speaks only of two coats, seems to have considered it. It appears, however, more proper to regard it as the inmost coat, and thus to conclude with Grew that the covers in most seeds are three. (*Ibid.* B. IV. ch. 3.) The coat last described must, in that case, be considered as the middle tunic, being situated between the outer

Of the Seed. one, and that which is continuous with the nucleus. In many seeds, however, only two coats are distinctly visible.

Uses of the Coats. 192. The foregoing tunics not only contain the nutrient matter, and afford a mechanical protection to the organic parts, but seem fitted also, by their chemical constitution, to resist the operation of agents that might otherwise effect their decomposition, and that of the nucleus they enclose. From the experiments of Fourcroy and Vauquelin, on the tunics of certain seeds that grow in marshy situations, it appears, that, beside the usual ingredients of vegetable substances, there exists in them a compound, formed by a combination of tannin with a peculiar matter of an animal nature, in union with a vegetable acid. This combination of tannin with the matter just mentioned, renders these tunics insoluble in water, and enables them to resist putrefaction, although buried for long periods in the moist earth. The tunics of those seeds, which do not possess this chemical constitution, may, it is added, by their ligneous or horny texture, or by the oily matter with which they are penetrated, present similar obstacles to the action of decomposing agents. (*An. du Mus. d'Hist. Nat.* Tom. XV. p. 77.)

### Article III.

*Description and Structure of the Nucleus of the Seed.*

Nucleus, its several Parts. 193. We proceed next to describe the parts contained within the above-mentioned coats or tunics, and which constitute the *nucleus* of the seed. These parts, as already observed, consist of the radicle, the plume, and cotyledons, together, in most instances, with the nutrient matter destined to support their future growth. The three former bodies are completely organized, but the nutrient matter is wholly inorganic, varies greatly in quantity and proportion in different seeds, and is very variously situated with respect to the organized parts.

194. These parts, which, in the progress of their evolution, give birth to the new vegetable, derive their visible origin from a medullary point, that succeeds to the act of fœcundation. By some, these organized parts have been called the *corculum;* by others, *embryo;* by others, *fœtus;* and by others, *plantula seminalis.* The primary point or particle, from which they originate, may, with propriety, says Gærtner, be termed *corculum,* since it is the source and seat of vegetable life, and from it the whole vascular system of the embryo proceeds. In some instances, this corculum increases so little as to be scarcely visible even in the mature seed; or exhibits only a palish spot, which has been termed *cicatricula.* In others, it forms a roundish radicle, whose apex is free, and rises above the nucleus, but whose base is firmly connected with it. In others, again, the corculum is still more disengaged, enlarging at each extremity, and producing at one end the radicle; and separating at the other into the two lobes called cotyledons, between which the first bud or plume of the future plant is situated. From this varying growth of the corculum, an embryo, more or less perfect, is produced. When the embryo presents only a mere germinating point, it is stiled *imperfect;* when it exhibits a simple radicle, it is deemed *incomplete;* when it possesses both radicle and cotyledon, it is considered *perfect;* and when it consists of radicle, cotyledon, and plume, it is pronounced *complete.* (*Gærtner de Fructib.* &c. Vol. I. cap. 13.)

Corculum. Embryo.

Description of the Embryo. 195. In the mature seeds of the less perfect plants, the embryo is altogether invisible until after germination, and even, in many other instances, its characters cannot be accurately traced. Its general figure is determined by that of the radicle and cotyledons, and is exceedingly various in different seeds. In size, it ranges from a minute point to that of a body of considerable magnitude. In consistence, it is almost always soft and herbaceous, but its radicle possesses sometimes a ligneous hardness. No seed contains more than one embryo, except in cases of *superfœtation,* of which Gærtner saw one instance in *Pinus Cembra,* a seed of which contained two embryos within one and the same cavity. (*De Fructib.* Vol. I. p. 168.) Malpighi also records a similar occurrence in a seed of *Prunus Armeniaca;* and the seeds of the *Gramineæ,* as will afterwards be shown, are capable of evolving an indefinite number of embryos. Every *complete* embryo is said to consist of three distinct parts, beside cotyledons. These are the radicle, the stem, and the plume.

Its Radicle. 196. The radicle (*radicula*), called *rostellum* by Linnæus, is the most constant part of the embryo, being found in some seeds, in which no other trace of that body can be discovered. In the seeds, however, of the less perfect plants, and even in those of some monocotyledons, no radicle is visible antecedent to germination. In some rare instances among dicotyledons, as in *Nelumbo nucifera,* no radicle exists; but, in germination, the stem first rises upward, and afterwards emits rootlets from its sides. (*An. du Mus. d'Hist. Nat.* Tom. XIII.)

197. The size of the radicle is very various, and so also is its figure, being either conical, cylindrical, filiform, or tubercular, &c. It always, says Gærtner, occurs solitary, except in *Secale, Triticum,* and *Hordeum,* to which alone, of all known seeds, three, four, or six radicles, properly formed, and distinct from each other, are furnished to each embryo. (*De Fructib.* &c. p. 169.) This plurality of radicles in the *cerealia* had before been remarked by Malpighi. M. Du Hamel describes the seed of Misletoe (*Viscum Album*), as emitting numerous radicles like those of wheat. (*Mém. de l'Acad. des Sciences,* 1740.)

Its Stem. 198. The stem (*scapus*) of the embryo is a continuation of the radicle, and connects it with the plume. It is frequently wanting altogether, nor, when it is present, can we fix precisely on the point where the radicle ends and the stem begins. What is called stem, descends frequently into the earth, and becomes a true root; so that every part of the embryo, situated beneath the cotyledons, might, without impropriety, be denominated radicle. The place of junction between the radicle and stem was called by Grew the *coarcture,* from its presenting often an evident degree of contraction; but M. Bonnet, and others, have given it the more appropriate name of the neck (*collum*) of the seed.

199. The plume (*plumula*) is the first bud of the

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new plant. In seeds that possess but one cotyledon, it is very generally wanting; and, even in those which have two cotyledons, it is not unfrequently absent, or is at least concealed within the stem. In most of the latter sort of seeds, however, the plume is met with. It is placed on the top of the stem or radicle, and lies between the cotyledons, by which it is variously compressed and folded on itself. In the greater number of seeds it is not entire, but, at its free end, is divided into several pieces, all closely couched together, like feathers in a bunch, and thence called the *plume* by Grew. In different seeds, its several little leaves vary much, both in figure, size, and number. The structure, both of the radicle and plume, will be most advantageously displayed in connection with that of the cotyledons.

The Cotyledons;

200. Of the organized parts of the seed, the organs called by Grew *lobes*, or *dissimilar leaves;* by Malpighi, *seminal leaves*, or cotyledons, remain to be described. The cotyledons derive their origin from the embryo itself, of which they constitute a part. The seeds, however, of some tribes of vegetables, as before remarked, are held not to possess these organs; and in many others, the mass of nutrient matter has been confounded with them. When present, they are either simple or divided. The simple cotyledon is formed by the mere extension of the corculum, and is in truth scarcely distinguishable from the stem itself. The double, or conjugate cotyledons, are produced by fissures which usually divide that part of the embryo that is opposed to the radicle, into two or more equal portions or lobes. These lobes have, at first, the appearance of mere tubercles, and in many seeds they retain this form unchanged; but, in others, they gradually expand into *lamellæ*, or plates, which augment in size, and finally exhibit the proper form of cotyledons. This form is very various, as likewise is the size of these organs. Sometimes they are so small as to be scarcely visible, and sometimes so large as to form the chief portion of the seed. Their substance is either thin, or thick, or turgid. Their colour is commonly white, but sometimes yellowish, purple, or green; the colour into which they all pass during germination.

their Structure.

201. Concerning the structure of the cotyledons, it may be said that, in the more perfectly developed seeds, they are formed of cellular tissue, through which vessels are everywhere distributed; and, as we have already remarked, they are everywhere covered by a fine pellicle, or coat, which prevents alike their adherence to the plume and to each other. This cellular structure of the cotyledon is well displayed by Grew (fig. 24. Pl. XV.) in a slice of the cotyledon of the recent bean; and it is easily seen in a thin slice of almost any mature seed, if it be held against the light after it has been soaked in water. This cellular structure extends into the radicle and plume, but in much smaller proportion, constituting, according to Grew, about $\frac{3}{5}$ths of the plume, $\frac{5}{7}$ths of the radicle, and $\frac{9}{10}$ths of the cotyledon.

202. Through all the organs that compose the nucleus, vessels are distributed, by the medium of which a general communication is established among them. This vascular system is likewise exhibited by Grew in the dissection of a Bean (fig. 26. Plate XV.), in which the vessels are seen to branch off on each side from the radicle, and spread themselves, by innumerable ramifications, through the cotyledons. From the radicle, vessels also pass upwards to the plume. These vessels of the radicle are visible when a transverse section is made through it, as in fig. 27. E, in which they are seen to occupy the middle of that body. When the section is made higher up at the neck of the embryo, as in the same fig. F, then the central trunk, surrounded by several smaller fasciculi of vessels, passing to the different parts of the plume, is still more clearly exposed. In many seeds, however, the organized parts are so small that their general structure cannot be traced, except during the progress of their germination. We shall therefore defer the description of them, till we come to treat of their evolution; and shall then also go more fully into the structure of the parts just mentioned.

Contain Albumen.

203. Within the cells of the cotyledon, in many dicotyledonous seeds, the nutrient matter, destined to support the future growth of the embryo, is entirely contained. In other instances, this matter is only in part received into those organs; and in the *Gramineæ*, and other monocotyledons, it is often placed almost entirely exterior to the cotyledon. This matter is produced from a clear liquor that is secreted in the tunic during the formation of the seed. To this liquor Grew gave the name of *albumen*, from its likeness not only in appearance, but, as he conceived, in use also, to the white of egg in animals. By Malpighi, this matter, considered in connection with the tissue that contains it, is often called the flesh *(caro)* of the seed; and from its being sometimes situated around the embryo, it has been denominated *perisperm* by M. Jussieu. We follow Grew and Gærtner in the use of the term *albumen*, meaning to express thereby, not the primary animal compound to which chemists have of late assigned that term, and which is found but in few vegetables; but that compound substance which, whatever be its situation, quantity, or colour, constitutes the nutrient matter of the seed.

Positions of the Embryo and Albumen.

204. This albumen is a very constant part of the mature seed, but its proportion, in some seeds, is so extremely small, that the seeds in which this occurs have been termed *exalbuminous;* and, in a few instances, it seems to be entirely wanting. Its quantity, situation, and figure, in different seeds, are subject to very great variation. In the seeds of the *Gramineæ*, where the embryo acquires only a very small size, the albumen constitutes almost the entire bulk of the seed, and is placed wholly exterior to the embryo. In the *Leguminosæ*, on the other hand, the embryo is more completely developed, and the whole of the albuminous matter is contained within the cotyledons. In beet *(Beta)*, and many others, the albumen is partly received into the cotyledons, and lies in part exterior to them; and where this occurs, the embryo sometimes encircles the albumen, and is sometimes encircled by it. In *Rheum*, the embryo is placed in the centre of the albumen; in *Rumex*, and some others, it is applied on the side of it; in *Atriplex*, the long cylindrical embryo surrounds the albumen; in *Böerhaavia*, the embryo and its cotyle-

Of the Seed. dons cover entirely the granulated substance of the albumen. (M. Jussieu, *An. du Mus. d'Hist. Nat.* Tom. V. p. 224.) In the Onion *(Allium cepa)*, the embryo makes several curves within the substance of the albumen; and in dodder *(Cuscuta)*, it is twisted around it in a spiral form; so that the relative positions of the embryo and albumen, as well as their quantity, proportion, and figure, are subject to endless variation.

Albumen of Wheat. 205. But however much, in these respects, the albumen may vary, it is always contained within an organized structure. Sometimes this structure is that of the cotyledon, as already exhibited in the Bean, fig. 24. the cells of which contain this albuminous matter. Where the albumen is placed exterior to the embryo, as in the seeds of Wheat, it is nevertheless contained in a cellular tissue. This is exhibited in fig. 25. Plate XV. copied from Leuwenhoeck, in which cells of an hexagonal form are seen to be filled with the albuminous particles that constitute the white matter or flour of that seed. This mealy part of Wheat he describes as consisting of minute globules, enclosed in a kind of membrane so exquisitely thin as scarcely to be observed, within which the globules are contained, as it were, in cells. The globules appeared to be of different sizes, not perfect spheres, but having an indentation on one part, which led him to suppose that they were not formed by simple accretion, but by some mode of growth, and that "the membranes which enclose them in cells, must be provided with so many veins or vessels, that every particle of meal may have its separate vessel." He even conceived the globules themselves to be enclosed individually in a thin skin or shell; but this opinion he never brought to ocular demonstration. (*Select Works by Hoole*, Vol. I. p. 169.) It may, therefore, be presumed that, in this instance, his imagination went beyond the powers of his microscope. Similar observations on the albuminous part of Wheat have since been given by Mirbel; and Kieser and others have delineated the globular particles contained in the cotyledonous cells of the Bean and other seeds; so that whether the albumen be situated in the cotyledons, or be placed exterior to them, it is, in every case, contained in a similar and distinctly organized structure.

Varieties of Albumen. 206. In consistence, the albumen varies; it is said to be either farinaceous, fleshy, or cartilaginous; and it may exist in various intermediate states. The farinaceous kind is readily reduced to powder, and is dissolved by water into a viscous mass. The embryo is generally placed exterior to this species of albumen, as in the *Gramineæ*. The fleshy albumen is more frequent. It is softer than the former, and dissolves by water into a gelatinous mass. It is often entirely contained within the embryo and its cotyledons, and yields the thick oil that is expressed from many seeds. Lastly, the cartilaginous species has a horny consistence, is difficultly soluble in water, and not easily reduced to powder. The embryo is never placed exterior to it, and when it contains oil, this is usually very thin. (*Gærtner de Fructib.* Vol. I. cap. x.)

Uses of Albumen. 207. In many seeds, the albumen serves as a support and defence to the embryo as well as for nutriment. If it be removed previous to germination, as was done by Mirbel (*An. du Mus. d'Hist. Nat.* Tom. XIII. p. 157.), in the seed of the onion, and by Dr Yule (*Wern. Trans.* Vol. I. p. 591.), in different species of *Gramineæ*, the embryo, though planted in a rich soil, and carefully tended, grows but feebly, and for the most part dies.

Vitellus. 208. Besides the albumen above described, Gærtner has revived the use of the term *vitellus*, but employed it to designate a very different part from that to which it was originally applied by Grew. The latter made use of this term to designate the inorganic matter of the mature seed, which, in the early stage of its production, he called albumen (*Anat. of Plants*, Book iv. ch. iii.); but it is employed by Gærtner to indicate a small membranous body, which, in many seeds, is placed between the embryo and albumen, and is closely connected with the former, but separates easily from the latter. The figure of this small body is described as being very various in different seeds. It is said not to rise out of the earth during germination; but, like the albumen, seems destined to afford nutriment to the embryo. It forms the chief bulk of the seeds of the *Cryptogamia*; and in those of the *Gramineæ*, it represents a thin scale interposed between the albumen and embryo, to which, from its shield-like form, he gives the name of *scutellum.* (*De Fructib. Plantar.* Vol. I. cap. xi.) There can be no doubt that this scutellum of Gærtner is the little "conglobate leaf" first observed in Wheat by Malpighi, and which later writers have denominated the cotyledon of that seed. In the next section, its form and situation will be clearly displayed.

### Section II.

#### *Of the Structure of Monocotyledonous Seeds, as displayed in their Evolution.*

Classification of Seeds: 209. All seeds have, by some botanists, been distinguished into such as possessed one or more cotyledons, and such as were entirely destitute of them; others maintain that every known seed possesses at least one cotyledon, and that no seed has more than two; and others again think there are some seeds which possess many cotyledons. It is not within our province to discuss the merits of these several opinions. We only beg to observe, that, in treating of seeds under the two divisions of Mono and Dicotyledons, we would not be understood to deny the existence of seeds that have no cotyledon, nor of others that possess more than two. We employ these words only as convenient general terms, under which the greater number of known seeds may be arranged.

their Evolution observed 210. Some seeds are so extremely minute, that, until lately, their existence was not clearly ascertained; and it is only during their germination that their general form and character can be detected. In many others, the organized parts are so small as to be scarcely capable of demonstration, except by following the progressive changes of form they exhibit in their evolution. We propose, therefore, to select, from each of the two divisions of Mono and Dicotyledonous seeds, an example or two of the successive appearances displayed in their evolution, which will,

Of the Seed. besides, form perhaps the best introduction to a knowledge of the structure of the mature plant. To the division of monocotyledons, the seeds of Mosses and Ferns have been referred, and with them, therefore, we shall commence our description.

in Mosses by Hedwig: 211. At the end of March, or beginning of April, Hedwig procured the mature capsules or ovaries of a species of Moss *(Mnium hygrometricum)*, and opening them over pots of earth, prepared to receive them, the fine dust of their seeds fell out. For several days they exhibited a dullish appearance, scarcely visible; but on the 7th day the surface became green. On the point of a needle, several of the young plantules were now taken up, and, being immersed in a drop of water, they were examined with a microscope that magnified 62 times. Innumerable seeds were visible, which had already put forth a very tender white radicle on one side, and on the opposite side a very simple obtuse corpuscle, extremely pellucid, and at its margin of a light green colour. Of these parts, a representation is given in fig. 28. G. Plate XV., in which the little globular body in the centre denotes the seed; and the radicle and lobe or cotyledon are seen, in opposite directions, to spring from it. The little node or seed was of a dusky colour, evidently swollen by the imbibition of moisture, and on its sides were marks of rupture made by the shooting forth of the radicle and cotyledon: these organs were themselves covered by an appropriate tunic. Sometimes, instead of one lobe, two or three sprang from the seed, as represented by the letter H. of the same figure.

212. In three days more, a second radicle issued from the seed, and the cotyledon also became divided into branches, as represented in fig. 29. For the next eight days, nothing remarkable occurred, except that the green colour increased in intensity. The proper leaves of the Moss now began to spring, and many succulent threads issued from the root. By the month of October, the young plantule was so much grown, that the parts of fructification could be distinguished. Its appearance, at this period, is exhibited, on a reduced scale, in fig. 30. Towards the end of November, the parts of fructification were completely developed, and from them seeds were obtained, which vegetated when committed to the earth in the following spring. From some other species of Mosses he obtained similar results, so as to leave no doubt that these plants are propagated by seeds, which at first put forth a radicle and cotyledon. (*Fundamentum Hist. Nat. Muscorum*, Pars 2da, p. 54.) His discoveries have been confirmed by several other botanists.

n Ferns: 213. In another order of the *Cryptogamia*, the Ferns (*filices*), the parts of fructification are placed on the back of the leaf, or *frons*, as it is termed by botanists. They there form clusters of small globules or capsules, which are secured in their place by a little scale. When the seeds are mature, the capsule bursts, and the seeds are scattered. Some observations were made on the germination of the seeds of se-

y Lindsay: veral species of Ferns by Mr Lindsay. In the climate of Jamaica, no alteration was visible in the seeds of *Polypodium lycopodioides* until about the 12th day after they had been sown, when they put on a greenish colour, and began to push out their little germ in the form of a small protuberance: this germ gradually enlarged, and exhibited, according to his delineations, several whimsical shapes, which subsequent observers have not been able to recognize. At length the green surface of the plantules assumed the form of small scales (fig. 31. Plate XV.), which appeared of a roundish figure, and somewhat bilobate, as seen in the enlarged view below. From this membranous leaf, a small leaf of a different figure afterwards sprang, which was followed by others, and in three months the developement was complete. (*Linnæan Transactions*, Vol. II. p. 93.)

by Mirbel: 214. With this last representation of the appearance of the germinating seed of the Fern, the observations of M. Mirbel coincide. He describes the seeds of the *Asplenium creticum* as producing, a few days after they are sown, a small heart-shaped cotyledonous leaf, represented of its natural size in fig. 32. It is formed entirely of cellular tissue, but exhibits no appearance of vessels. After some time, numerous small threads shoot from its point, corresponding in office to the radicle of ordinary seeds; and at length a plume, in the form of a crook, is said to shoot from the same part. Gradually, the cordiform figure of the cotyledon disappears, and it seems as if made up of two lobes, from the middle of which the crook-shaped plume continues to grow. (*An. du Mus. d'Hist. Nat.* Tom. XIII. p. 71.) See fig. 33. Plate XV., and its enlarged representation below.

by Yule. 215. The germination of these minute seeds has also lately been observed by Dr Yule; and his account differs, in some particulars, from that of his predecessors. He describes the first appearance of the young plantule, as resembling a dark green point, which, when closely examined, exhibits the form of *two* seminal leaves, rising out of the seed, and gradually expanding to the diameter of more than a quarter of an inch. From a circular opening in these seminal leaves, the frond or permanent leaf arises, and is afterwards followed by a second. He regards the first leaves as cotyledons, within which the embryo is included, and from which it springs, as in dicotyledonous seeds. He notices also, the absence of vessels in these cotyledonous leaves, and the circumstance of their emitting minute rootlets, by which they derive nourishment, previous to the shooting of the true root. His observations have been given to the public, in the article "*Filices*," in a contemporary work, the *Edinburgh Encyclopædia*.

Evolution of Wheat. 216. In most of the seeds of this division, the cotyledon does not, however, appear above the soil during germination, but is retained within the coats of the seed, and consequently undergoes but little alteration in size. As an example of the evolution of a monocotyledonous seed, we shall select that of Wheat (*Triticum hybernum*), because its developement has been studied with great care, and, in common with some others of the same natural family, it exhibits some striking peculiarities, which add greatly to its productive powers. The successive appearances exhibited in its evolution, have been given with great accuracy by Malpighi, who has carried its anatomy farther, in some points, than most of his successors.

Of the Seed.

In the earlier stages of growth, some very accurate representations of it have also been given by M. Poiteau, and Dr Yule has likewise obliged us with some valuable observations. From these different authorities, confirmed generally by our own observations, we shall endeavour to present a concise view of the structure and evolution of this very important seed.

Description of Wheat.

217. If we take a grain of Wheat, and examine its convex side, we observe, at its base, a small oblong body, fig. 34. Plate XV. lying in a semicircular depression, which is well defined through the tunics that cover it. These tunics are two in number, an outer one, to which the chaffy filaments at the vertex of the seed are attached, and which readily separates when moistened; and an inner one, which everywhere adheres closely to the cellular tissue that contains the albumen. If these two tunics be raised and thrown back, as is done in fig. 35. the little oblong body ($h$), with its semilunar appendage ($i$) placed behind it, are brought into view; and together, they constitute the embryo.

218. Let next a vertical section of another seed be made in the direction of the furrow that runs along its flatter side, and let this section pass through the embryo, as is represented in fig. 36.—we then observe the seed to be composed almost entirely of albumen ($k$), with which the embryo ($l$), consisting of minute convoluted leaves, is in close contact. The part of the embryo that is applied against the albumen is the cotyledon, which, on that surface, is convex, and on the opposite one concave.

219. In fig. 37. the entire embryo has been removed from its connection with the albumen, and a front view of it, considerably magnified, is there given, in which the letter $o$ denotes the cotyledon, in the concavity of which the plume ($n$) is lodged, and ($m$) indicates the protuberances from which the radicles afterwards spring. If now, this same embryo be reversed, as is done in fig. 38, then the convex back of the cotyledon only is seen, with the extremity of the principal radicle at the base. It is this side of the cotyledon that was applied against the albumen; and its polished surface, says M. Poiteau, proves that it nowhere adhered by any organic structure. Gærtner also remarks, that the connection between these parts is not organic, but merely superficial—an observation that is true, as far as relates to the embryo itself and the albuminous matter, but not as applied to the tunics which envelope them; for, at the base of the seed, the inner membrane, which contains the albumen, appears to be continuous, as Leuwenhoeck remarked, with that which covers the cotyledon, being reflected from the albumen over the cotyledon, much in the same way as the *pleura* and *peritonæum*, that line the sides of the great cavities in animal bodies, are reflected over the *viscera* they contain. Such are the appearances presented by this seed antecedent to germination; let us next follow it through the several stages of that process.

Germination of Wheat observed

220. After a seed of this species has been in contact for 24 or 30 hours, with the humidity necessary to its germination, its embryo becomes swollen, and when removed from the other parts, and moderately magnified, presents the appearance exhibited in fig. 39. In this figure, the radicle is rendered more protuberant, and the fine tunic that invests it has undergone an alteration, being changed from a smooth, opaque, and solid texture, to one that is villose, transparent, and cellular. A vertical section of the same embryo, as exhibited in the next figure (40.), shows the elongation of the principal radicle ($p$) which caused the protuberance below, and the sprouting of the two lateral radicles ($pp$), which push forth more slowly on the sides. These three radicles soon force their way through the sac that envelopes them, which then forms sheaths around their origins: In the same figure, the letter $q$ denotes the plume, consisting of several convoluted leaves, and resting on the cotyledon. In fig. 41. the appearance of the seed, in a stage a little more advanced, is exhibited. The plume ($r$) is now seen to have risen above the cotyledon ($s$), and the three radicles, surrounded at their origins by their proper sheaths, have greatly increased in length, and innumerable capillary rootlets are emitted from their sides. (*An. du Mus. d'Hist. Nat.* Tom. XIII. p. 383.)

by Poiteau

by Malpighi:

221. The daily appearances exhibited in the evolution of this seed, as previously given by Malpighi (*Anat. Plantar.* p. 103.), accord well with the above representations of M. Poiteau; and he has noticed some additional particulars of considerable importance. On the first day of germination, he represents the plume of the embryo as beginning to open, and the protuberances, which indicate the eruption of the three radicles, as beginning to form. The radicles, at this period, are completely enveloped in a membranous sac or involucrum; and the body of the embryo is closely connected with a "conglobate farinaceous leaf by which nutriment is administered." This conglobate leaf is the cotyledon before-mentioned, and its connection with the radicle and plume is well shown by Malpighi. In fig. 41. (I.) he exhibits a front view of the radicle and plume, as they appear when separated from the cotyledon; and at the letter K. of the same figure, a back view of the same body is displayed, in which the letter $t'$ points to the mark or scar that denotes the place of separation. Malpighi believed these parts to be united with each other by a little node, hereafter to be described; but it is by the medium of vessels that this connection between the cotyledon and the other parts of the embryo is maintained; and by this route alone can the nutrient matter or albumen be conveyed through the cotyledon to the radicle and plume. To these vessels M. Bonnet gave the distinctive appellation of *mammary:* the union they form between the different parts of the embryo is so close, that, at this part, says Gærtner, the cotyledon, and radicle, and plume, form one undivided body. (*Gærtner de Fructib. Plantar.* Vol. I. p. 149.)

on the 1st day:

the 2d day

222. On the second day of germination, the exterior tunic of the seed, according to Malpighi, gives way; the plume rises upward; the radicles do not as yet pierce their investing sac, but this sac is turgid with juice, and is covered exteriorly by a fine white down: the cotyledon, also, at this period, is rendered moist.

the 3d day

During the third day, the cotyledon is quite turgid with juice; the plume is much enlarged, and be-

Of the Seed. gins to look green; the three radicles have pierced the enveloping sac, and are everywhere thickly covered with hairs; and above the two first lateral radicles, two small protuberances, *v. z.* fig. 43, the origins of two more radicles, are now seen to emerge, while the sac that envelopes them is observed sensibly to waste.

4th day: 223. When the third day has elapsed, the plume, enclosed in a fine transparent membrane, is still more elevated, and acquires a greenish colour; the protuberances of the two new radicles are more prominent, and the three former radicles have greatly augmented; the cotyledon is much softer, and as if milky, yielding, when compressed, a white and sweetish liquor.

5th day: 224. After the completion of the fourth day, the plume *w*, fig. 44. continuing to ascend, pierces the membranous covering *x*, and pushes into day a permanent leaf, green and convoluted, around which the membrane forms a sheath. Inferiorly, the three first radicles have greatly extended, and the two others *yy*, are much increased: the outer coat of the seed now begins to lessen, but still contains a sweetish liquor. M. Poiteau gives a section of the entire plantule about this period of its growth, which agrees very exactly with the figure of Malpighi. In this section, fig. 45. the plume $a'$ is seen to have pierced the membrane $b'$ that formerly enclosed it; the albumen $c'$ is diminished; the cotyledon $d'$ retains its situation and form; and the five radicles $e'e'$ are nearly of a length, and covered with hairs.

6th day: 225. About the sixth day, the plantule, still invested by its sheath, begins to open and expand; the seminal tunics shrink, and the surface of the outer coat is corrugated. If these tunics are cut open, the cotyledon within is observed, in some parts, to be firmer than before, and has the appearance of a concave leaf; but in other parts, it is more vascular, and filled with juice, especially in that part near to the *mammary* vessels.

11th day: 226. After the eleventh day, these tunics still adhere to the plantule, but appear much wasted, and the juice they contain is mixed with bubbles of air; while the stem, forming many knots, and the radicles emitting innumerable rootlets, continually augment in size. Where the vegetation has been very active, the whole original contents of the seminal tunics are by this time exhausted, and, when compressed, they yield only a watery fluid.

28th day. 227. After the lapse of a month, when the parts, already developed, are still farther advanced, new buds break out from the primary seat of growth and rise upward; and new radicles push forth and descend. So readily are these radicles produced, that sometimes, if the primary ones be removed, others in crowds spring forth; at the same time, new buds or shoots, protected in their proper sheaths, arise from the same part, and, surrounding the primary plantule, are borne upward with it. Of these appearances accurate delineations are given, and they may be observed in every field of growing wheat.

Error of Malpighi: 228. The foregoing descriptions of Malpighi are, in general, very correct, and his figures, though somewhat rude, exhibit, as usual, faithful delineations of the objects they are destined to represent. In one or two points, however, he has fallen into error, which, in the above statement of his opinions, to avoid confusion, we corrected as we went along. Thus, though he distinctly points out the "conglobate farinaceous leaf," as the organ by which nutriment is administered to the radicle and plume; he assigns to the sac that, in an early state, envelopes the radicles, the function of *placentula;* and even gives to the exterior tunic of the seed the title of seminal leaf. The true cotyledon, however (which never in this seed is produced into a seminal leaf), is the little conglobate body above mentioned; and the common tunics of the seed have no title to the appellation of seminal leaves. To this cotyledon, Gærtner, from its shield-like form, gave, as before observed, the name of *scutellum.* He held it to be characteristic of the *gramineæ*, and analogous to the organ to which, in some other seeds, he gave the name of *vitellus.* (*De Fructib. Plantar.* Vol. I. p. 139.) But most later writers, as Jussieu, Smith, Brown, and Poiteau, have all restored to it its proper office of cotyledon. of Gærtner:

229. M. Poiteau has gone even farther, and asserted the existence of a second cotyledon in this seed, and in the oat, which he describes as situated directly opposite to the former. (*An. du Mus. d'Hist. Nat.* Tom. XIII. p. 388.) In this instance, however, he has mistaken the rudiment of the second bud for a second cotyledon, as Dr Yule ascertained by "tracing the growth of this supposed cotyledon from its first becoming visible, to its final developement as a plant." (*Werner. Transac.* Vol. I. p. 594.) M. Mirbel considers the sac that invests the plantule to be the cotyledon of this seed; and this cotyledon to form the *first ensheathing leaf.* (*An. du Mus. d'Hist. Nat.* Tom. XIII. p. 148.) But, as already remarked, the cotyledon never, in this seed, rises out of the tunics; and, as Dr Yule observes, differs totally in situation, structure, and consistence, from the ensheathing leaf of the plantule. of Poiteau: of Mirbel.

230. A very remarkable peculiarity in this family of plants is their great productive power, as displayed in the indefinite number of new plants which we have seen to be evolved from one primary seed. Malpighi not only observed this peculiarity, but has described the structure from which it originates. He considered the radicle and plume of the embryo to be connected with the cotyledon, not by the mammary vessels, as we have stated, but by a little body which he called the *umbilical node.* In a section of the lower part of the stem of the plantule, made after the third day of germination, he delineates this node as situated at the junction of the radicle and plume, as represented by the letter $f'$, fig. 46. Plate XV.; and describes it as solid exteriorly, and softer and more medullary within. If a section of the same part be made on the fourth day, as in fig. 47. the stem ($g'$) of the plantule will be seen, says he, to spring from this node, from which also the radicles equally take their origin. Peculiarity of Structure in Wheat. Opinion of Malpighi:

231. This peculiar property in the *Gramineæ*, was also observed by Leuwenhoeck, though he seems not clearly to have apprehended the nature of the organs from which it proceeded. In the embryo of wheat he describes three points, from which not only of Leuwenhoeck.

Of the Seed. three distinct radicles spring; but they are also, he adds, "the beginnings of three several spires or stalks of wheat; so that from every grain of wheat (which is well worthy of observation), there will arise not merely a single stalk, but three distinct ones, which are formed in the seed itself." *Select Works by Hoole*, Vol. I. p. 169; and in Vol. II. p. 289, are to be found similar observations on the seeds of Oats, Barley, and Rye.

of Mirbel: 232. By M. Mirbel, the umbilical node of Malpighi is considered as a fleshy knot *(un nœud charnu)*, by the medium of which the plume and radicle are united. The lateral radicles, which issue from it, he regards as distinct in their nature from the primary one, and as resembling those which spring from knots in the stem; he therefore names them *articular* roots, *les racines articulaires*. (*An. du Mus. d'Hist. Nat.* Tom. XIII. p. 149.) According to Dr Yule, however, this fleshy knot is to be considered as a *tuber*, analogous to the tuberous substance, interposed between the bulbs and roots of the *Liliaceæ* and other monocotyledonous tribes; and which is destined to produce an indefinite number of young plants, a greater or less number of which are subsequently evolved by the joint agency of the roots and leaves. The "articular roots" of M. Mirbel he regards as in reality young plants, the roots of the *Gramineæ* being invariably fibrous. It is by means of these lateral shoots and their *tubera*, that bushes, consisting of from sixty to several hundred stems, are sometimes seen to originate from one seed.

of Yule:

233. The above important peculiarities in the germination of the seeds of the *Gramineæ*, are very perspicuously displayed by Dr Yule in the three figures which we have copied from his Memoir. In fig. 48. Plate XV. Dr Yule represents the embryo of wheat as it appears when detached from the albumen, a short time after germination has commenced; the ascent of the plume covered with its membrane, and descent of the three primary radicles, which have pierced their containing sac, are clearly exhibited, and the letter $h'$ points to the little cotyledon, placed at the junction of the two parts just mentioned. In fig. 49. the germination of the same seed is shown in a more advanced stage; the plume ($i'$) has now risen to a considerable height, and pierced the investing membrane; and at $k'$ a second bud or plume (which M. Poiteau mistook for a second cotyledon), is seen to shoot from the tuber like the first: the letter $l'$ denotes the seminal tunics. At a still more advanced period, four young plants, $m'$ $m'$ $m'$ $m'$, fig. 50. of the second month, with their sheaths in part withered, are seen to have sprung from the same part; but the two seminal tunics of the seed, exhausted of their contents, still remain attached, as indicated by the letter $n'$. (*Wernerian Trans.* Vol. I. p. 589.)

234. The description given above of the evolution of wheat is applicable, with little variation, to the seeds of all the *cerealia*. The seed of the Oat emits from four to six radicles, all of which break through their enveloping sac at the same place, and thus appear to be contained in one sheath; such too is the case with Barley, the plume of which extends beneath the seminal tunics, and pushes out at the vertex of the seed. Of the Seed.

235. This peculiar constitution of the seeds of the *Gramineæ*, is attended with important advantages in their culture, and explains the source of their great productive power. A single grain of Barley was observed by Du Hamel to have produced 200 ears, each of which yielded 24 grains; so that one single seed planted in a good soil, has produced 4800 grains. Curtis and others, by transplantation of the several plantules of Wheat, obtained still higher returns from single seeds. For the same reason, these plants are better enabled than others to resist the injurious effects of accident or disease. If a seed, says Dr Yule, be buried under a stone or lump of indurated clay, the seminal plantules cannot shoot upward; but stems are then sent off in a horizontal direction, until they can effect their escape upward. Sometimes it happens, that a small insect (*Musca pumilionis*) deposits its egg in Wheat, and the grub is lodged in the very centre of the stem, just above the root, by which the stem is invariably destroyed, and the root so materially injured, as to prevent its throwing out fresh shoots on each side, or *stocking* itself, as the farmers term it. Nevertheless, the plants thus attacked are not permanently injured; for, in the instance where these depredations occurred, the crop of Wheat was good, and the ears large and fine through the whole field; so that these injured plants, by the production of lateral shoots, yielded an abundant crop. (*Lin. Trans.* Vol. II. p. 76.)

Productiveness of Wheat.

236. In the germination of other monocotyledonous seeds, a similar succession of phenomena present themselves, with the exception of those which relate to the multiplication of so many individuals from a single seed, and which seem to be peculiar to the *Gramineæ*. In all, the radicle first shoots forth, and the plume soon follows; the cotyledon is commonly of small size, and is retained within the tunics. As the embryo grows, the albumen is taken up and conveyed through the cotyledon to the young plantule; and, before the albumen is exhausted, the embryo is enabled to draw its nutriment from the soil in which it grows. Evolution of other Seeds.

237. In many instances, it appears, that the primary radicle of these seeds, after a short time, becomes dry, and falls off, and is replaced by a great number of secondary rootlets. M. Poiteau regards this last circumstance as common and peculiar to monocotyledonous seeds. He has remarked it in many hundred palms, not one of which had a descending or tap-root. No plant in the numerous family of the *Liliaceæ* is said to possess such a root. The radicle of the *Cyperaceæ* does not, perhaps, perish so soon, but it does not continue long. This premature and constant destruction of the radicle he considers as the cause of the bulbs and truncations which occur, particularly in the *Liliaceæ*; for the lateral roots not being capable of receiving all the descending sap, it collects at the lower part of the stem, and occasions these different enlargements. (*An. du Mus. d'Hist. Nat.* Tom. XIII. p. 392.) Destruction of the Radicle by Nature:

238. The effects which thus succeed to the spon-

Of the Seed. taneous destruction of the radicle, occur partly in other plants, in which the first radicle is naturally permanent, if it be artificially removed. Du Hamel found, that, if the extremity of permanent radicles were cut off, lateral rootlets were produced; that even mechanical obstruction to the descent of the radicle frequently gave rise to divisions in it, and the production of these lateral rootlets. He ascertained, also, by experiment, that roots extend invariably, not by an elongation of parts already formed, but by new matter added to their extremities; and hence it is, that roots, whether ligneous or herbaceous, do not elongate, if even the smallest portion of their extremity be cut off. (*Phys. des Arbres*, Tom. I. p. 83.) The results of observations on the growth of Carrots, in different soils, by Mr Knight, correspond with those of M. Du Hamel.

by Art.

### Section III.

*Of the Structure of Dicotyledonous Seeds, as displayed in their Evolution.*

Modes of Evolution.

239. From the greater number of seeds which have two cotyledons, the phenomena of their evolution may be expected to exhibit at least as great variety as those of the division last described. In different species they differ in this respect as much from one another, as they do from monocotyledonous seeds. Some seeds of this class raise their cotyledons above ground during germination; in others, these organs are wholly retained within the tunics. Of each of these modes of evolution we propose to give an example, selecting, as before, those seeds which have been most accurately observed, or which, by the forms they exhibit, seem best calculated to illustrate the general laws, by which their evolution is accomplished.

240. In the seeds of this division the embryo is commonly much more completely developed than in those of the class last described; so that the several organs of the plantule become distinctly visible. The radicle and plume are readily distinguished, and the cotyledons are frequently so large as to form nearly the entire mass of the seed. Within the cotyledons, the albuminous matter provided for the nutrition of the embryo during its evolution, is often entirely contained; and these organs, as before remarked, rise sometimes out of the earth, increase greatly in size, and, after a certain period, decay. In other instances, no increase in size, nor elevation above the surface, occurs; but, like the greater number of monocotyledons, they remain beneath the soil, and yield gradually their nutrient matter for the support of the embryo. Even in plants of the same natural order, the *Papilionaceæ*, for example, some, as *lupinus*, says Dr Smith, raise their cotyledons into the air and light; while others, as *lathyrus*, retain them under ground, concealed within the tunics of the seed. As an example of the latter, we shall give from Malpighi an abridged account of the successive appearances exhibited by the common pea *(pisum)*, which, in its evolution, approaches, in some respects, to that of the seeds last described.

Evolution of the Pea.

241. The figure and size of this seed are familiar to every one. After being placed for a day in circumstances favourable to its germination, it is much increased in size; its outer coat is rendered softer, and becomes more white and thin; the umbilical aperture continues closed, but near to it an irregular opening or laceration is visible. If the outer coat be now stripped off, the *nucleus* comes into view. It is seen to consist of two distinct parts or lobes, which are the proper cotyledons of the seed. These cotyledons are closely invested by the inner tunic; externally they have a convex surface, but internally, where they are in contact, their surfaces are nearly plain. Between them, in a small depression formed in their substance, lies the plume; it is composed of a number of yellowish leaves, folded on each other, and bent inward, and is united by a little curved stem, to a small white conical body, the radicle. These appearances are exhibited in fig. 1. Plate XVI., in which one of the cotyledons has been removed, so that the inner surface of the other, together with the plume and radicle, are fully brought into view: the letter *a* denotes the cotyledon, *b* the plume, and *c* the radicle. This radicle at its neck, or point of junction with the stem, sends off on each side a little stalk or pedicle to each cotyledon. In the above figure, one of these pedicles has been cut through, and the other, that remains attached to the cotyledon, is concealed behind the plume. It is by these pedicles alone that the two cotyledons are connected with each other. — 1st day:

2d day:

242. When the second day of germination is completed, the cotyledons are rendered more tumid, the tunics give way, and the radicle begins to protrude. Soon after, the cotyledons separate a little, and become somewhat concave internally. After the third day, the radicle has pushed out through the tunics; it is white, except at its point, which is more deeply coloured, and it emits on all sides fine capillary rootlets; the cotyledons are now farther separated, and by degrees the stem of the embryo, with its curved plume, are disclosed.

5th day:

243. About the fifth day, the stem (*d.* fig. 2.) mounts upwards: it is white, and bears on its summit the plume (*e*) still curved, and now becoming green: the stem now also begins to exhibit the marks of knots at particular parts: the radicle (*f*) is farther advanced, and small protuberances, the origins of future rootlets, appear on it: the cotyledons (*g*) retain their place, are turgid and solid, and still surrounded by the lacerated tunics.

7th day:

244. At the close of the seventh day, the plantule is much more advanced; the knots on the stem (*h. h.* fig. 3.) are quite distinct, and its apex is furnished with broad green leaves, but which are not as yet unfolded. The substance of the cotyledons is still solid, and when compressed, yields a bitterish juice: the radicle is much elongated, and has emitted numerous rootlets.

9th day.

245. After the ninth day, the plantule is completely formed: its stem (*i.* fig. 4.) is now erect, and the leaves of the plume (*k*) are expanded: the cotyledons (*l*) are reduced in size: and the radicle (*m*) or root, as it may now be termed, with its numerous rootlets, is greatly augmented. Every part of the plantule, except the cotyledons, continues daily to increase; at

Of the Seed. the end of a month, these organs are still found to adhere; but are wrinkled, thin, and exhausted of their nutrient matter, with which the stem and other organs are filled.

Evolution of the Gourd.

246. The progress of evolution in those seeds that raise their cotyledons above the earth, is exhibited by Malpighi in that of the Gourd (*Cucurbita.*) This seed is of an oblong figure, and has a flattened form. It possesses three distinct coats or tunics: the outer one is thick, tough, and coriaceous; the middle one thin, membranous, and of a greenish colour; and the inmost is that transparent colourless pellicle that closely invests, and is inseparably connected with, the cotyledons of the seed.

247. After this seed has been made to imbibe moisture, the outer and middle tunics readily separate, and expose the *nucleus*, which is seen to consist of two leaf-like cotyledons, which have no connection with each other, except by the medium of the little conical body, or radicle, at their base. The size and figure of these cotyledons, and the situation of the radicle that connects them, are represented in fig. 5. Plate XVI. Their external surface exhibits to the naked eye prominent lines which indicate a vascular structure, the vessels of which proceed from the radicle at their base. They are commonly five in number, and from their main fascicular trunks, ramifications are produced, which, in their distribution, form a finely reticulated appearance over the whole organ. On their inner side, the cotyledons are quite plain, and closely applied against each other, but, as already remarked, are nowhere connected, except at the base. This surface is displayed in figure 6, in which the great vascularity of the organ is rendered more apparent. It is between the two cotyledons that the plume, consisting of minute convoluted leaves, is lodged and cherished. In figure 7., a part of the nucleus of this seed is represented a little enlarged, and the two cotyledons have been removed at different places by transverse sections, to show more clearly the situation of the radicle and plume. The letter *n* denotes the place from which one of the cotyledons has been removed, so as to bring the plume (*o*) into view, and *p* points to the conical radicle below.

1st day:

248. When this seed has been twenty-four hours in circumstances favourable to its germination, it is rendered tumid, and the umbilical aperture at its base is enlarged by the swelling of the parts within: the cotyledons become turgid, and the plume is augmented in size. After the second day the outer coat is much softened, the middle one appears as if torn and decaying, and all the parts within still farther augmented in size. During the third day, the colour of the outer tunic becomes darker; the cotyledons are more swollen; their vessels more conspicuous, and the radicle pushes out through the umbilical aperture.

4th day:

249. When the fourth day has elapsed, the plantule is still retained within the tunics, and if these be now removed and examined, the middle one is found to be dry and thin; the cotyledons (*q*, fig. 8.) are whitish, soft, and flexible, but the vessels on their surface are much more distinct; the radicle (*r*) is elongated and covered with down, as likewise is the stem (*s*). At the top of the radicle, a protuberance is seen, which is white and soft; and farther down appear several smaller tumours, indicating the places of rootlets about to break out. Of the Seed.

6th day:

250. About the sixth day, the cotyledons *q*, fig. 9. emerge from beneath the tunics, representing the "dissimilar leaves" of Grew, and the "seminal leaves" of Malpighi, but which we shall, in future, denominate *cotyledonous leaves*. They are thick, soft, and a little separated from each other; their position is pendent; their colour yellowish; they are very vascular, and between them the plume is still concealed. The radicle (*r*), at this period, is much elongated, and rootlets everywhere spring from its sides; the stem (*s*) is also lengthened and curved, and, in common with the radicle, is everywhere covered with a white curling down.

9th day:

251. Towards the ninth day the cotyledonous leaves (*q*, fig. 10.) assume an erect position. At their points, they are still yellowish, but elsewhere green, and their cellular tissue is filled with a greenish yellow juice; they begin to separate a little, but still entirely conceal the plume. The stem (*s*) at this period is greatly elongated, and its lower extremity has become green; the protuberance that existed at this part is greatly lessened; and below it, the radicle (*r*) is continued, from which numerous rootlets, covered with fine capillary productions, break out.

21st day.

252. During the following days, the cotyledonous leaves continue to enlarge, the stem to elongate, and the plume to augment in size; but it is not yet unfolded. About the twenty-first day, the developement of the plantule appears to be completed. A representation of its foliage at this period, is given in fig. 11.; the cotyledonous leaves (*q*) have now reached a great size, are of a deep green colour, and very vascular; they rise, by a short pedicle, from the summit of the stem. On each leaf, seven fasciculi of vessels are visible, which, beyond the middle, terminate in a net-work, from which is produced the cellular structure that contributes to form the breadth of the leaf. In the axil, formed by the cotyledonous leaves, the plume (*t*) lay concealed; it is now disclosed by the removal of one of those leaves. At first, the leaves of the plume are curled and convoluted, but afterwards they expand, and their figure is then seen to differ entirely from that of the cotyledonous leaves; they have notched margins, and their surface is covered with down. In this manner the young plant continues to increase, and acquires at length its full magnitude, in the progress towards which the cotyledonous leaves waste gradually, and finally fall.

Evolution of other Seeds.

253. The seeds of the Radish (*Raphanus*), of the Lettuce (*Lactuca*), and of the Kidney-bean (*Phaseolus*), are represented by Malpighi as exhibiting, in their evolution, a similar succession of appearances. In all these seeds, and in many others of this division, the radicle first pierces the seminal tunics; next the cotyledons come into view, and assume generally the form of leaves, between which the tender plume is for a time concealed, and at a later period is disclosed. In different seeds, however, the forms of these organs, and the periods of their successive evo-

Of the Seed.

lution, are subject to the greatest variation, not only as relates to the species of seed, but to the soil, the climate, and season in which it is destined to grow.

Internal Structure of the Pea:

254. Having thus surveyed the changes in *external* form, which the germinating seed exhibits, we shall conclude our description by a display of the peculiarities of its *internal* structure. This we shall find to consist entirely of vessels and cellular tissue, variously proportioned and combined. In a longitudinal section of the radicle of the Pea, in an early stage, Malpighi represents it, as in fig. 12. to be composed entirely of cellular tissue exteriorly, in the centre of which the vascular system, separating at the top into three divisions, to supply the plume and cotyledons, is placed. A similar section of the radicle (fig. 13.), on the seventh day, exhibits corresponding sections of the rootlets it puts forth, which are seen also to consist of cellular tissue, and of vessels that come off from the central fasciculus of the radicle.

255. The stem, when about a month old, is composed of a thick bark formed of cellular tissue, within which are two rings of vessels, as seen in the transverse section, fig. 14. The inner ring ($v$) is said to consist of sap and spiral vessels; and exterior to this, a zone of vessels ($w$), yielding a peculiar juice, is said to be placed. In some very thin slices of the stem of the pea, viewed through a microscope of considerable power, the arrangement and distribution of the vessels and cellular tissue appeared to us as represented in fig. 20. The centre of the stem was occupied by cellular tissue, round which was a zone of vessels ($v$), forming four principal fasciculi. Exterior to this zone was a small ring of thickened cellular tissue, and beyond this, the proper cellular substance of the bark. Near the circumference of the stem were four larger fasciculi, which may probably be considered as the "proper vessels," while those near the centre may be deemed the sap-vessels.

of the Gourd:

256. In the plantule of the Gourd, a similar structure is observable. Fig. 15. exhibits a longitudinal section of the plume and radicle of that seed, considerably magnified, as they appear before germination, and shows the position of the vessels $x$, as they pass up towards the plume $y$. In the next figure (16.), a similar section of a radicle, on the second day of germination, is shown, in which the vessels that form the rootlets are seen to originate from the fasciculi that exist in the radicle. In figure 17. is represented a longitudinal section of the stem and radicle of the same plantule on the ninth day. In the stem, the vessels are disposed in a circle that surrounds the pith; but as they descend towards the root, they approach each other, and give off ramifications to form the rootlets. In a transverse section of the stem, on the 21st day, Malpighi describes it as hollow in the centre, fig. 18. around which six fasciculi of vessels are disposed, and the intermediate portion is occupied by cellular tissue. Hedwig, however, and Kieser, enumerate not fewer than ten fasciculi of vessels in the stem of this plant, some of which are placed next the pith, and others near to the bark.

of the Bean.

257. To these representations of the structure of the Pea and Gourd by Malpighi, we shall add that of the Bean, in its early stages, as delineated by Grew, who has traced the distribution of the vessels in the radicle and cotyledons with great minuteness. In fig. 19. is exhibited a vertical section of a young Bean, which is made to pass through the cotyledons, the plume, and radicle. From the extremity of the radicle, the vessels ascend in fasciculi to the neck of the plantule, where they are seen to diverge towards each cotyledon, and ramify through it, while a central vascular portion is continued to the plume. In fig. 21. the vascular and cellular structure of the germinating Bean, at an early period, are shown in conjunction, in a highly magnified representation, presented here in a reduced size from Grew. In this figure, $a'$ denotes the cotyledon; $b'$ the enveloping tunics; $c'$ the cellular tissue; $d'$ the vascular system continued from the fasciculus $e'$ in the radicle, and ramified through the substance of the cotyledon; the letter $f'$ points to the plume, which also receives vessels from those of the radicle; and $g'$ indicates a depression in the cotyledon, in which, antecedent to germination, the plume was partly lodged; a similar depression existed in the other corresponding cotyledon.

Of the Trunk.

## CHAP. II.

### THE ANATOMY OF THE MEMBERS OF VEGETABLES.

### SECTION I.

### *Of the Structure of the Stem or Trunk.*

#### ARTICLE I.

#### *Of the Stem in Herbs.*

Stems.

258. In the foregoing chapter we have traced the successive changes of form which the seed exhibits in its progress to constitute the perfect plant; we have next to display the structure of the plant itself, in its more remarkable varieties and forms. The leading features of this structure have already been laid before the reader, when discoursing on the *common textures* of plants; it remains now to exhibit individual examples of it, as they occur in the several members of the trunk, the branch, and the root.

Varieties of Structure.

259. We have already noticed the very striking difference in the proportion and arrangement of the elementary organs, which obtains in different plants. While in some, the component textures are perfectly distinct from each other, in others, they are completely blended together; so that the characteristic distinctions of pith, and bark, and wood, are entirely lost. M. Desfontaines, as we remarked, has sought to connect this diversity of structure in the stem with certain peculiarities in the form of the seed; but it will appear, as we proceed in our descriptions, that such limitations and circumscriptions are perfectly arbitrary; and that Nature does not move by saltations, as the systems of naturalists would prescribe; but by a progress so gradual, and advances so continuous, that the lines and boundaries which denote the perfection of *artificial* classification, are, in truth, but so many evidences of the immaturity of *natural* knowledge. In the case of Ferns,

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the structure of whose seeds has been displayed in a preceding section, we have a striking example of the insufficiency of this theory; for, while the stem possesses that simplicity of structure, which is said to appertain only to plants that spring from monocotyledonous seeds, the seed itself appears, from the observations of Dr Yule (214.), to belong clearly to the division of dicotyledons. Without any reference, therefore, to the form of the seed, we shall exhibit the structure of the stem and trunk of different plants, as they appear on dissection, beginning with the more simple, and proceeding gradually to the more complex forms.

Names of Stems.

260. Botanists employ different terms to distinguish the different kinds of stems or stalks that support the leaves, and the organs of fructification. These are the stem (*caulis*), which is considered peculiar to herbaceous plants, and the trunk (*truncus*), which is proper to herbs and trees; the straw (*culmus*), which is the appropriate stem of the grasses; and the stalk (*scapus*), which differs from the other varieties in bearing only flowers, but not leaves. For the peculiarities in external form and character, which distinguish these several kinds of stems, as they occur in different species of plants, we must refer to the writers on botany; and shall proceed to exhibit a general outline of their internal structure.

Stem of Sugar-Cane.

261. Perhaps there is no plant in which the simplicity of vegetable organization is more clearly displayed than in the Sugar-cane, which belongs to the family of *Gramineæ*. In its stem or culm, the cells and vessels are comparatively large, retain much of their more perfect forms, and are quite distinct from each other. When treating of the cellular tissue (82.), we referred to the cells of this plant, exhibited in the very thin transverse slice, fig. 22. Plate XVI. as illustrative of their hexagonal figure, and of their being bounded, on every side, apparently by a single membrane. In some parts, when the observer is viewing these cells through the microscope, some of them appear quite transparent, from the upper and lower bounding membranes being entirely removed, and the light, in consequence, being freely transmitted; but in others, one or both of these membranes remain, and, though they are exquisitely thin, yet, when viewed by a strongly reflected light, a degree of refraction seems to be produced, which communicates to the surface of the membrane an irregular appearance, such as it has been attempted to express in the darker cells of the same figure. The deception that arises from viewing two layers of these cells in conjunction, which imparts the appearance of double sides, as in fig. 23. was before noticed; and the longitudinal appearance of the same organs, as seen both in a single and double series of columns (figures 24. and 25.), was at the same time described.

262. It is through this cellular structure that the vessels, which constitute the other component part of the culm of this plant, are distributed. They occur in fasciculi, which, towards the centre, are placed at considerable distances from each other, and preserve a symmetrical arrangement; but nearer to the circumference, they are more numerous, and their distribution is much less regular. In fig. 26. Plate XVI. a very thin transverse slice of this plant is exhibited, in which this regular disposition of the vessels at and near the centre ($h'k$), and their crowded state near the circumference ($i'$), are well shown; the cells, too, at the centre, are larger, and have a more perfect form than those near the circumference of the figure. In fig. 27. a very thin longitudinal slice of this same plant is delineated; it is considerably magnified; the letter $l'$ denotes the cellular tissue, and $m'm'$ two fasciculi of vessels which ascend through it.

Of the Palm.

263. In the Palm, which, though belonging to the division of trees, we shall notice in this place, a similar disposition of the elementary organs is observed; but both the vessels and cells are smaller than in the Sugar-cane, and the fasciculi of vessels are also much more numerous. This structure is exhibited in the transverse section of the trunk of the Palm, fig. 28., in which the dark spots indicate the vascular fasciculi, and the whiter portion the cellular tissue. As before observed in the Sugar-cane, the vessels are seen to be less numerous at the centre than at the circumference, where they are much crowded together, and very irregularly distributed, in consequence of the peculiar mode in which the growth of these trees is accomplished.

264. In fig. 29. of the same Plate, we have also copied from M. Desfontaines a portion of the longitudinal section of the trunk of another species of Palm (*Dracæna draco*), which displays more clearly the irregular direction which the vessels take in the lax cellular tissue through which they are distributed. It was before remarked, that these plants do not naturally produce branches; but that their vascular system is expended wholly in the production of leaves at their summit, and their trunk is perfectly cylindrical. If, however, the top of the plant has been cut off, or broken by accident, a division into branches is said to take place. (*Mém. de l'Instit. Nat.* Tom. I. p. 486.)

Of Asparagus.

265. In the stem of Asparagus, the elementary organs possess an arrangement similar to that of Palms; but in the progress of its growth, branches are given off continually, and consequently the stem diminishes in size as it ascends. In fig. 30. is given a vertical section of a part of the stem ($o$) of this plant, at that period of growth in which it is usually brought to table; the buds $p'p'p'$, protected by the imbricated leaves, present a very beautiful appearance. At each place where a bud springs, a part of the vessels of the trunk go off to form it, and are finally expended in its production; the diameter of the trunk above is consequently diminished, and the more central vessels are continued on, to be successively employed in a similar manner, till they terminate in a bud at the apex. We have thus an example where, though the elementary organs are uniformly distributed, as in Palms, yet, in consequence of the production of lateral branches, the diameter of the stem continually diminishes, and assumes the form of a cone, in which it differs from that of the Palm and Sugar-cane.

266. As in these plants the ligneous and cortical textures are uniformly blended together through the

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entire stem, it must be presumed that the *sap*-vessels and *proper* vessels are everywhere associated. This fact is accordingly pointed out by Malpighi as occurring in several species of the *Gramineæ*, who, as we before remarked (62.), delineates a *proper* vessel as existing in each fasciculus of sap-vessels.

Stem of the Gourd,

267. The next variety of structure we shall notice, is that of certain herbaceous plants, in which the proportion of cellular tissue in the stem very much exceeds that of vessels, and in many of their characters they come near to the plants last described. In the sections already given (figures 18. and 20. Plate XVI.) of the stems of the Pea and Gourd, the greater portion of the stem is seen to be made up of cellular tissue, but several fasciculi of vessels are dispersed through it. In fig. 31. Plate XVI. is a transverse section of the stem of the Gourd, of its natural

by Hedwig:

magnitude, copied from Hedwig, in which the dark spots indicate the relative positions of the ten fasciculi of vessels that are observed in this plant. In fig. 32. a small portion of the preceding figure, comprehending only two fasciculi of vessels $rr'$, and highly magnified, is exhibited; the vessels are seen to be of different sizes, and, by their enlargement, they press upon and diminish the size of the neighbouring cells; the cells themselves are also of different sizes; in some parts, as denoted by the letter $q'$, they are comparatively large. Their figure is generally hexagonal, though not always regularly so; and near to the vessels, they exhibit various irregular shapes. A very fine cellular tissue, placed exterior to the outer range of vascular fasciculi, forms the cortical texture of this stem, and from the succulent cuticle jointed hairs of various sizes are seen to spring; the centre of the stem is hollow. (*Fundament. Hist. Nat. Muscor.*)

by Kieser.

268. The stem of this plant has been examined with great minuteness by M. Kieser, who has represented, in several sections, both transverse and longitudinal, its appearance in different parts, and at different periods of its growth. The number of fasciculi that exist in the mature stem he makes, with Hedwig, to be ten; but the number of vessels in each fasciculus varies at different periods, and even in the different parts of the same plant. In a mature plant, the number in each fasciculus, near to the summit, does not exceed six or seven; below the first knot from the top they are more in number; below the second knot, they amount to nineteen; and they increase in number in the next internodial space. In the centre of the stem, there are twenty-three vessels in each fasciculus; and near to the root, when examined in autumn, they amount to twenty-nine. In the trunk of the root, ten fasciculi of vessels may also be reckoned; but in the principal rootlets only four fasciculi are observed, each of which contains thirty-seven vessels.

269. The size and general characters of these vessels are represented as varying with age, not less than their numbers, and hence they have different forms in different parts of the same plant. At an early period, when few in number, they are very small near the summit of the plant, and consist only of *simple spiral vessels;* in a later period, and lower down on the stem, they are of larger size, and some of them exhibit the characters of *annular spirals;* in the third internodial space, their size is still greater, and two or three of them are now transformed into *punctuated spirals;* and still lower on the stem, the number of punctuated spirals is increased. In the centre of the mature stem, *six large punctuated spirals* are visible, and near to the root, in autumn, of the twenty-nine vessels that compose each fasciculus, *twenty-three are punctuated spirals*, and only six simple spiral vessels are now to be seen. The characters of these vessels now also approach to those of arborescent plants; their sides are thickened, and their transparency is almost lost, and the cavities of some of them are filled by membranous vesicles, which form within them a sort of cellular tissue. In the root, at this period, the simple spiral vessels have altogether disappeared, and only punctuated spirals, smaller than those in the stem, can be discovered. This successive disappearance of the simple spirals, and augmentation in the number of the punctuated variety, is urged by M. Kieser as a proof of the transformation of the one into the other during the progress of vegetation. No mention is made of the existence of proper vessels in these fasciculi; and the representations of the cellular tissue, of the ligneous texture, and of the bark, correspond with those given by Hedwig. (*Mém. sur l'Organisat. des Plantes*, p. 134.)

270. In the stem of the Gourd, as thus described, we observe an arrangement of parts in many respects according with that of the Sugar-cane. In both, the cells are large, and their figure is well preserved; and the vessels are distributed in distinct fasciculi through the cellular tissue. In the Gourd, however, the vessels are fewer in number, and do not suffer that displacement, during the progress of vegetation, which those of the Cane experience. In neither plant are the vessels so numerous, or so situate, as to compress the cellular tissue into transverse partitions, nor is there, in the transverse section of either, any appearance of concentric layers. In neither stem is there any proper pith, the central part of the Sugar-cane being occupied by cells and vessels, and that of the Gourd being alike destitute of both. The cortical texture of the Gourd is represented as composed entirely of cellular tissue; but in it probably are situated the *proper* vessels, whose place has not yet been accurately noted.

271. In the sections of various herbaceous stems, represented by Grew and Malpighi, the number of vessels, and their disposition, exhibit the greatest variety, and approach more or less to the arrangement of parts that is found in shrubs and trees. Thus, in Holly-hock (*Alcea*), Grew describes the vessels of the bark as yielding a thin mucilage, and within them are the sap-vessels, postured in short rays, which comprise twelve or sixteen vessels. In *Scorzonera*, the "proper vessels" in the bark yield a milky fluid, and are postured in a radiated manner with the sap and spiral vessels that extend to the pith, all of which form parts of the same radiated lines. (*Anat. of Plants*, p. 103.) In Endive, Malpighi describes the structure of the stem as approaching in character to that of trees. Near the circumference the vessels, says he, are disposed in lines directed towards the centre, and are separated by small ranges of cellular tissue, which is compressed into a solid and dense form; and more interiorly, the vessels are larger, and

Other Stems, by Grew; by Malpighi.

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extend a considerable way in rays through the stem. (*Anat. Plantar.* p. 25.) Where the vessels have this radiated position, the cellular tissue between them assumes the form of membranous partitions; but the greater portion of the stem of this plant is occupied by cellular tissue, not thus compressed into a membranous form. We thus clearly observe that, even in herbaceous stems, membranous partitions, extending more or less completely through the stem, are formed, whensoever the vessels are disposed in radii, and are sufficiently numerous to compress, on either side, the cellular tissue that envelopes them.

### Article II.

### *Of the Trunk in Shrubs and Trees.*

Structure of Trunks.

272. In shrubs and trees, the several textures that compose the trunk are commonly distinct from each other; and some parts that are but imperfectly distinguished in herbs, become in them well defined. In the trunks of these plants, however, though a general uniformity of structure is observed, yet particular modifications of it exist in every species, and these are still farther varied by the peculiar nature of the individual plant, and the mode and circumstances of its vegetation. Before descending to particular examples, it may be useful to exhibit a concise view of the parts that compose the trunk, and the terms employed to denote them.

The Skin.

273. Externally in every tree we have the skin or cuticle, the structure of which has been already described in a former section. In very young plants, and in young branches, it is succulent, and its surface is entire; but in older trunks and branches, it is frequently dried and broken, and, in some instances, is thrown off; so that the exterior covering of the plant appears to be formed by the cellular tissue of the cortical texture.

The Bark.

274. Beneath the skin is the bark, constructed, as we have seen, of cellular tissue, and of vessels collected into fasciculi, which at first are strait, and run parallel to each other; but, by the subsequent augmentation of the parts within, are separated at certain places, and touch only at a few points, so as to form a reticulated appearance. In the annual shoot, only a single ring of vessels is observed, and these, with the tissue in which they are placed, form the *cortical layer*, as it has been called, of that period. Within this layer, a new production of vessels and of cellular tissue takes place, and this being annually repeated, constitutes the series of layers of which the bark is ultimately composed. The new layer that is thus annually formed, and which appears to exercise an active vegetative function, was more particularly distinguished by the appellation of *Liber* by the ancients, from its being the substance on which, before the invention of paper, they were accustomed to write. Very frequently, instead of a ring, the vessels of the bark are collected into distinct parcels or clusters, which, in the progress of vegetation, assume very different shapes.

Its Cortical Layers.

Its Liber.

The Wood.

275. Next to the bark is placed the wood, constructed, like the bark, of vessels and cellular tissue. Like it, too, it consists in the young plant, and in the annual shoot of the older one, of a single ring of vessels, which immediately surrounds the pith. In the following year, a new ring of vessels is formed around the first, and in every succeeding year this process is repeated; so that the wood consists at length of a series of rings enclosing each other, and the number of which denotes the age of the tree. The outer ring of newly formed vessels is more succulent than those of older growth, and is generally of a whiter colour; whence it has received the names of sap-wood or *alburnum*. By Du Hamel, and most French writers, it was named *aubier*, and by Hill it was called the *blea*. In every annual shoot, the newly formed liber and alburnum are in contact; but in every succeeding year they are separated more and more from each other by the interposition of new matter between them; so that at length the first layer of bark, and the first ring of wood, occupy respectively positions the most distant; those, namely, of the centre and circumference of the tree.

Its Alburnum.

Its Radiated Vessels.

276. The vessels that are thus annually formed, and constitute the alburnum, are disposed in *radii* which extend more or less completely from the circumference to the centre. In some trees, the vessels are much more numerous than in others; and, in the progress of vegetation, they frequently suffer great alterations in size and external figure, as was before observed when treating of the vascular system. In the alburnum the size of the vessels is very uniform, and so it continues ever after in some trees; but, in others, it is very various, some being enlarged more than others by a greater influx of sap. With this increase of size, the vessels seem to acquire the spiral character. They are also frequently closed up, in the more aged parts of trees, by the production of vesicles within their cavities; and, in common with the smaller vessels and the cells, they are, in some trees, ultimately filled with gummy or resinous matter. In other instances, where the proper juices of the plant differ but little in quality from the common sap, the vessels, when no longer employed in active vegetation, become dry, and appear, in some plants, like empty capillary tubes, and, in others, from the minuteness of their size, no aperture is visible. In this state, they have been regarded as solid filaments, and denominated the *ligneous fibres* of the plant.

Ligneous Fibres.

Transverse Septa.

277. From the disposition of the vessels in *radii* more or less regular, the cellular tissue, by which they are surrounded, will be more or less compressed in the same direction, and form those transverse partitions between the several rays of vessels, which we have already so frequently noticed. In addition to these fine partitions, described both by Grew and Malpighi, which are thus *interposed between* every ray or line of vessels, larger portions of cellular tissue are observed, at certain distances, which extend in the same direction through the wood, and, in some instances, are continued through the bark also. By the authors just mentioned, these partitions were described as stretching from the bark towards the pith, and were named *insertments* by Grew, and *transverse utricular ranges* by Malpighi. Others have held them to proceed rather from the pith to the bark, and have called them *medullary rays*. We shall venture to name them, in future, *transverse septa*, which name

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denotes simply their direction, and the fact of their forming partitions between the vessels, without expressing any opinion concerning their origin. For similar reasons, the finer partitions of cellular tissue, previously described, may be denominated the lesser transverse *septa*.

Longitudinal Septa.

278. Beside these transverse septa, there are sometimes portions of cellular tissue intercepted between the vessels in a longitudinal direction. This was remarked, both by Grew and Malpighi, in the oak and several other trees: they appear sometimes to be very short, and sometimes to form nearly a continuous ring around the trunk. It is probable they are formed simply by the pressure of the vessels acting in a direction opposite to that by which the transverse septa are produced; they may, for distinction sake, be named the *longitudinal septa*. In many trees, they are not to be observed, or, if they exist, are so thin as to form only a sort of *fascia* on the adjacent vessels. To the cellular tissue, promiscuously intermingled with the vessels, some writers give the name of *parenchyme* of the wood.

Parenchyme.

The Pith.

279. The only other part of the trunk that remains to be mentioned is the pith. It is situated at the centre, and is surrounded commonly by a ring of vessels, but sometimes, in part, by thickened cellular tissue. Its proportion in shrubs is usually much larger than in trees; and in the young shoots of trees it occupies more space than in the older branches. At first in the young plant it is succulent, but afterwards becomes dry; and in aged trees it frequently is entirely obliterated, or at least rendered solid.

280. In a description of the growth of the trunk in a young plant of chesnut, Malpighi has given clear views of the gradual developement of these several parts, and exhibited the appearances successively displayed in the first years of growth. (*Anat. Plantar.* p. 35.) In the Vine, some of these parts are very distinct. Fig. 1. Plate XVII., represents a transverse section of the annual shoot of this plant. The pith ($a$) in the centre is large, and composed of cells of different sizes. From the pith to the skin in the Vine, and, according to Grew, in the Elm and some other trees, extend the transverse septa ($b$). In some places, the cellular structure of these septa in the recent plant is still visible, as at ($c$); but generally they have the appearance of thickened membranes. Between every two septa, two, or sometimes three lines or rays of sap-vessels are interposed, which, from their size, are readily visible, and their place and disposition are indicated by the dotted marks ($d$): the circular ring that bounds these vessels seems to be formed of condensed cellular tissue, and exterior to it the proper vessels are placed in the cellular tissue of the bark.

Trunk of the Vine:

of the Apple:

281. In the next figure (fig. 2.) is exhibited the transverse section of an Apple-branch of one year's growth, which, like the former, is considerably magnified. The angulated figure and relative size of the pith at this period are shown: from the pith to the bark proceed numerous very fine septa, possessing somewhat of a curved direction, and between them innumerable black points, indicating the sap-vessels, are seen: these vessels are disposed in radii, and are bounded exteriorly by the thickened tissue of the bark: the bark is proportionally large, and in the midst of its cellular tissue clusters of proper vessels ($g$) are observed.

282. In a similar section of the Apple-branch of two years growth, fig. 3., more highly magnified, the pith ($h$) is seen to have assumed a rounder form: from the pith towards the bark the transverse septa extend, between which the vascular radii are situate. The letter $i$ denotes the place of junction of the two years growth; $k$ the newly formed alburnous vessels, situate between the bark and the wood; and $l$ two ranges of "proper vessels," placed in the cellular tissue of the bark. Grew gives a highly magnified view of a section of this same plant about the third year of its growth, in the 25th table of his work, the appearances of which correspond with those just related, except that the transverse septa, as in all his figures, are made to represent strait lines, which, in the earlier periods of vegetable growth, does not appear to be quite correct.

283. Proceeding next to the plant of more mature age, we shall copy from Grew part of a section of the Oak, which in fig. 4. is exhibited on a reduced scale. The letter $m$ denotes the bark; $n$ the alburnum; $o$ the wood; and $p$ the pith. In this section, the larger transverse septa ($q$), and the smaller ones ($r$), are very distinct, between which the sap-vessels of different sizes, indicated by the dark points, are situate: the letter $s$ points to the proper vessels of the bark, some of which are collected into round parcels, and others form a ring.

of the Oak:

284. Beside the transverse septa that intersect the diameter of the tree, we observe, in this figure, other lines ($t$) placed at right angles to them, and which appear to be interposed between each annual ring of wood. Grew considered it probable that these lines were produced in the Oak, and also in the Fig-tree and Walnut, by a peculiar sort of sap-vessels that existed once in the bark, as did the turpentine vessels distributed through the wood of the Pine. (*Anat. of Plants*, p. 115.) Hill also calls them sap-vessels, seated on the outer edge of each annual circle, which, in the young plant, contain sometimes a limpid liquor, and, at other times, appear empty. He notices also the existence of proper vessels, containing a thick juice, in the alburnum of this tree. (*On the Construction of Timber*, p. 9.)

of very old Oak.

285. An examination of this wood at an age still more advanced, may contribute to throw some farther light on its structure. In fig. 5. is given the representation of a transverse section of the central portion of a piece of the wood of very old Oak, of its natural size and appearance. The pith ($w$) at the centre was completely obstructed, and its cellular character obliterated; the letters $x$ $x$ $x$ denote the larger transverse septa, rendered completely solid everywhere, and in some places partially obliterated; and ($y$) the white lines that extend in the opposite direction, and mark the boundaries of each year's growth. In the substance of these concentric lines, numerous traces of minute apertures were visible, and from one line to another, small irregularly curved lines, as represented in the drawing, were everywhere observed to extend. No vacuity was anywhere perceived to exist, but the whole formed one compact and solid mass.

286. A small and very thin slice of this wood,

Of the Trunk.

comprising a part of one of the larger transverse septa, and small portions of two of the concentric lines above mentioned, was submitted to a pretty highly magnifying power, and a delineation of its appearance is given in figure 6. In this figure, the letters $a'$ $a'$ denote the two concentric lines; $b'$ one of the smaller irregular lines that frequently extend from $a'$ to $a'$, but are often intercepted, and form irregular spots or patches, as traced in several parts of the drawing; $c'$, the smaller transverse septa, situated at unequal distances from each other; and $d'$, the larger septum, the cellular character of which is entirely obliterated. Several small irregular lines, running in the same direction with the larger concentric ones, are also observed; these, at their junctions with the lesser transverse septa, produce a number of little squares, the areæ of which are filled up with a dotted or punctuated membrane.

Structure of Oak,

287. This microscopical representation seems to confirm the opinion of Grew, that the concentric lines ($a'$ $a'$) are chiefly composed of vessels; for their apertures, now rendered visible, are of different sizes, and the canal of many of the larger ones is filled up with a vesicular substance, often observed in the vessels of aged plants. The substance that surrounds these vessels appears to be condensed cellular tissue, rendered perfectly solid by the resinous matter with which it is filled. The irregular thickened lines ($b'$) that run transversely to the former, are similarly composed of vessels and condensed cellular tissue, and the smaller patches, we have noticed, are made up of the same; both the large and small transverse septa consist of condensed cellular tissue alone, and such, too, appears to be the matter of which the fine lines or longitudinal septa that intersect them are composed. Some observations of Du Hamel, on the formation of the ligneous layers, may aid our inquiries into the nature of these latter septa, and the minute structure of the wood.

by Du Hamel;

288. In a transverse section of the trunk of the Oak, the Elm, or the Fir, says this very intelligent writer, the ligneous layers are distinctly visible, and it is commonly believed that each of these layers is the product of one year's growth. If, however, we cut obliquely a piece of Oak, each layer is then seen, with the aid of a common lens, to be composed of a number of thinner layers, which mutually cover each other. By macerating pieces of wood in water, he was able to separate the annual layers into a great number of leaflets thinner than the finest paper; and these primary layers, as they may be called, he afterwards ascertained, by experiment, to be formed successively during the whole period of active vegetation; so that the layer which is the product of one year's growth, is itself formed of a number of layers exceedingly thin. (*Phys. des Arb.* Tom. I. p. 31, and Tom. II. p. 19.)

Now, it is probable that, between each of these primary layers, cellular tissue is interposed; and this tissue, by its compression, gives origin to the minute lines which in this tree have been noticed. In several trees, however, no similar lines are visible, because, in all probability, they do not, like the Oak, afford secretions by which the tissue is thickened and rendered apparent. Even in a very thin slice of Oak, when viewed in the microscope by a strongly reflected light, these lines almost entirely vanish, while those of the two orders of proper transverse septa remain.

by Kieser.

289. M. Kieser examined the same wood, in the transverse slice of a tree of 100 years of age (*Mém. sur l'Organisat.* &c. Plate XIV.), and his representation of its structure is copied in figure 22. Plate XVII. In this figure, in which the appearances are magnified 130 times, $n$ $n$ $n$ represent the cellular tissue, or, as he calls it, the parenchyme of the wood. At the top and bottom the cells are obstructed, and appear like obscure points (as is the case also in fig. 6. of the same Plate); but in the middle of the figure, the cavities of the cells are said to be still visible: the letters $o$ $o$ denote the apertures of enlarged spiral vessels, all of which were filled with vesicles, but a few only are so represented, as in $p$ $p$; $q$ indicates the smaller vessels dispersed through the cellular tissue; $r$ a portion of one of the larger septa, and $s$ the smaller ones, which are often displaced by the augmentation in the size of the vessels.

290. In this highly magnified representation by Kieser, there is no appearance of the concentric lines or septa which intersect the transverse ones, as noticed by Grew and Malpighi, and exhibited in figures 5. and 6.; but the two orders of transverse septa remain. We before remarked, that, in a slice of wood so very thin, as, when viewed by a strong light, to become translucent, these lines, in a great measure, vanished, and in the figure of M. Kieser, this evanescence is made to extend even to the thickened portion that intercepts the annual layers. It is therefore probable, that all these appearances of concentric or longitudinal septa, are produced simply by the thickening and compression of the cellular tissue in the Oak, and such other trees as have viscid juices, and whose vessels are subject to irregular enlargement; for in whatever position these thickenings occur, numerous vessels are always to be observed. Hence, in very thin slices they entirely vanish, while the proper transverse septa, being formed by the condensation of continuous portions of membrane, remain visible. In these figures, it may also be remarked, that the surface occupied by cellular tissue seems equal nearly to that occupied by vessels; but it is probable that the apertures of many minute vessels dispersed through the tissue, have not been distinguished from the cells. In a highly magnified representation, however, of the wood of this tree by Grew (*Anat. of Plants*, tab. 3. fig. 7.), the proportion of the vascular to what is deemed the cellular part is still less.

Bark of Oak.

291. The vessels of the bark in the Oak, as delineated by Grew, fig. 4. Plate XVII. are represented as disposed partly in parcels, and partly in a ring; and in all the representations he has given of different trees, the greatest diversity, in regard to the position of these vessels, is found to exist. From the difference in the qualities of their juices, in the texture of the parts, and in the modes and circumstances of their growth, this variation may be expected to occur. In the Oak, the Pine, and many others, it seems certain also, that a part of the cortical texture, or at least vessels containing the proper juices of the plant, are constantly mixed with those of the ligneous texture, and with them contribute to form each an-

Of the Branch. nual layer of wood. In this respect, therefore, these trees may be said to approximate in structure to Palms, and those trees in which the two textures are uniformly blended, in some of which, the growth is said to take place at the circumference, as in ordinary trees. For examples of the diversity of structure exhibited in the trunk of a great many different trees, we must refer to the beautifully executed plates of Grew.

### Section II.

### *Of the Structure of the Branch and its Appendages.*

#### Article I.

#### *Of the Branch.*

The Branch. 292. From the trunk springs the branch, which, in structure, resembles very exactly that of the trunk itself. Indeed, most of the figures, which represent the structure of the trunk, are taken from sections of the branch; and hence the description of the one serves entirely for that of the other.

293. Branches, in common with leaves, originate from buds, of which we have subsequently to treat, introductory to a description of leaves. At present, we shall describe only the mode of connection between the trunk and the branch.

Its Connection with the Trunk. 294. The branch, says Grew, springs not from the surface, but so deep as to take with it not only the bark and the wood, but the pith also, making its way at the parts where the vessels are separated by the transverse septa, and carrying with it the skin, which is extended with it. (*Anat. of Plants*, p. 28.) The separation of the vessels of the trunk to form the branch is not like the separation of a few filaments from a skein of thread; but they spring, says Du Hamel, from a centre, and bear with them a part of each portion of the tree. Hence if a tree, that is divided into two branches, be cut a foot above the bifurcation, the surface of the sections resembles that of two trunks cut horizontally: if the section be made lower down, at the place where the branches spring, the same appearances of two series of concentric circles are seen at the axis of the trunk, but they are surrounded by other layers common to those which belong to each of the branches; and still lower on the trunk, the concentric circles belonging to each branch, diminish, and are finally lost in those which form the trunk from which they sprang. (*Phys. des Arbres*, Tom. I. p. 93.) These primary branches divide into others, and these again into still smaller branches, which form angles with each other, more or less great, according to the species of tree and other causes.

295. The position of the branches on different trees is very various, but in the same species it is generally uniform. From the measurements of Du Hamel, it appears that, in many trees, the solid matter of the branches that go out from the trunk, exceeds that of the trunk itself in the proportion nearly of five to four. (*Phys. des Arbres*, Tom. I. p. 96.)

Origin of Branches, 296. Parent and others have supposed that the branches proceeded always from, and were nourished by, the pith; but this opinion has been combated by Du Hamel and Hill. The latter gives a longitudinal section of the trunk of a species of American Dog-wood (copied in fig. 7. Plate XVII.), representing the origin of two buds ($ff$), which are seen in the state of pushing out on either side through the vessels of the wood. In this trunk, the pith is of a brown colour, the inmost ring of vessels green, and the outer ones white. Through the white rings, the inner green vessels are seen to shoot, and the brown pith is left entire behind; though the new branch at length obtains a pith for itself, which, however, has no connection with that of the trunk. In a similar section of an older trunk (fig. 8.), the branches are seen to spring also from the inmost circle of wood: the pith ($g$) is not at all disturbed, but each branch is furnished with its own pith $h\ h$. In a section of the Vine, fig. 9. a similar origin of the branches, from the inmost circle of wood, is observed; and not only is the pith ($i$) of the branch distinct from that of the trunk, but the pith of the trunk itself is intercepted by the shooting of a branch ($k$) across it. (*On the Construction of Timber*, p. 35.) This latter fact of the interception of the pith by the shooting of branches across it, was previously noticed by Grew in the Vine and some other plants. (*Anat. of Plants*, tab. 19.) Of the Branch. by Hill.

297. When a bud thus protrudes to form a branch, the perpendicular vessels of the trunk are compelled to separate, and they afterwards meet above, and pursue their former direction. This is shown in fig. 11. Plate XVII. copied from Du Hamel, in which the bud $p'$, in the act of sprouting, is seen to push to either side the vessels of the trunk, which again meet above it.

298. The vessels, both of the wood and bark, according to the same author, have their direction determined chiefly by the course of the sap. If the sap preserve a perpendicular direction, as in trees that have no branches, the vessels are perpendicular also; but if it move to one side, these vessels then change their direction. This is strikingly evinced in a tree that has been cut over above a branch; for then all the sap being obliged to pass to the young branch, the vessels all at once take the same direction; so that if a tree has been cut over in winter, and at the end of the succeeding spring, its branch below be examined, the new vessels of the branch will be seen to cross those of the trunk, as exhibited in fig. 12. $q'$, Plate XVII. (*Phys. des Arbres*, Tom. II. p. 53.)

299. In figures 7. 8. and 9. copied from Hill, the young branch, in every instance, is seen to originate from the most inmost ring of vessels that surrounds the pith; and he was of opinion that all buds and branches sprang from this part alone. To this vascular circle he gave the name of *corona*, and held it to be the most important part of the vegetable body, that it was like no other part of the plant, but contained within itself the essence of them all. (*On the Construction of Timber*, p. 21.) Corona.

300. It is however notorious, that trees in which not only this first circle, but almost every other circle of vessels has perished, produce leaves and shoots from the trunk where the bark is entire, as this author himself admits, p. 44 of his work.

Of the Branch.

There does not appear, either in the anatomical character, or in the functions of this circle, anything that distinguishes it from the others, except priority of formation, and its being, in consequence, the seat from which the *first* buds and branches spring.

Origin of Branches by Du Hamel.

301. A much more correct idea of the origin of buds and branches was entertained by Du Hamel, who illustrates it by the diagram, fig. 10. Plate XVII. Let us suppose this figure to represent a tree of four years growth, as indicated by the four ligneous cones which, at its base, envelope each other. In the first year, a bud ($l'$) springs from the inmost ring, which, by the fourth year, is seen to consist of four ligneous layers. In the second year, a second bud ($m'$) springs from the ring of that year, and consists only of three layers; the next year, a bud ($n'$) is developed on the first bud $l'$, and possesses only two layers; and the bud $o'$, developed the fourth year on the outmost ring of wood, is seen to consist only of one layer. (*Phys. des Arbres*, Tom. II. p. 53.) In this way, every ligneous layer may be considered equally capable of giving origin to buds and branches.

### Article II.

### *Of Thorns.*

Thorns are Abortive Branches.

302. Connected both in origin and in structure with branches are those appendages, frequently observed upon them, called thorns. They are very conspicuous on the hawthorn, and are constituted, says Grew, of the same parts as the bud itself, and in a like proportion. They spring from the outer portion of the ligneous texture, and may be considered as abortive buds. (*Anat. of Plants*, p. 33.) Malpighi describes them as being frequently produced in the axils of leaves, and to assume for a time the form of a branch; but at length to degenerate into a thorn. He considers them to arise from defective nutrition, and adds, that they disappear frequently under higher culture. (*Anat. Plantar.* p. 138.)

According to Willdenow, most species of our fruit-trees naturally possess thorns, but which disappear entirely and become branches, under higher culture. Even in the Black-thorn, the prickles diminish in number under improved culture, but do not entirely disappear.

Other Origins of Thorns.

303. Sometimes, however, instead of being produced from abortive buds, thorns owe their origin to the degeneration of other organs; the petioles of some pinnate leaves which are persistent become thorns, and the same thing is observed of the peduncles of some flowers. Certain stipulæ, also, as those of Mimosa, are said sometimes to change into thorns (*Principles of Botany*, p. 270.); and in the Date, according to M. Decandolle, a lobe of the leaf has been converted into a thorn. (*Théorie Elément. de la Botanique*, p. 344.) In other instances, as in the Holly, the leaf produces thorns round its entire margin, which are formed by the vessels that bound it. See fig. 11. Plate XVIII.

Structure.

304. When the bark is removed from a branch that possesses thorns, the thorns still remain, by which they are distinguished from prickles that originate from the bark. In fig. 20. Plate XVIII. is a representation of a branch deprived of its bark, in which thorns of different forms are seen to spring from the ligneous texture; and in fig. 21. of the same Plate, is a longitudinal section of another branch covered with its bark, in which the ligneous and cortical textures of the Thorn are displayed. For the descriptions of the varieties of thorns, and their external appearance, we must refer to the writers on botany.

### Article III.

### *Of Claspers and Tendrils.*

Description.

305. From the similarity in structure which these bodies exhibit to the branches from which they spring, we have placed them as appendages to those members. As is well known, they are met with only in certain plants, and their obvious use is to attach the different parts of the plant to one another, for mutual support, or to the objects in their neighbourhood. In a general manner, they are denominated *fulcra*; the most remarkable species are those which, like the claws of Ivy, called *claviculi* by Malpighi, are not rolled into a spiral form, and those of the Vine, named tendrils (*cirri*), which possess a spiral conformation.

Structure of Claspers.

306. According to Malpighi, the claws or claspers of Ivy possess a roundish form, and are covered with hairs, which yield a viscous humour, by which they are agglutinated to stones or to walls and trees. Their forms are exhibited in fig. 22. $e'$ $f'$, Plate XVIII. copied from Malpighi; and in the lower part ($g'$) of the same figure, their origin and structure are displayed; they are seen to spring from the ligneous texture of the stem, and to possess a similar structure.

of Tendrils.

307. The tendril is described by the same author as springing from knots between the origin of leaves. It possesses a round stem, which is sometimes covered with hairs, and this stem frequently divides into several branches. At first it is very tender, but gradually acquires solidity, and assumes the spiral character; its colour is green, and it is composed, like the trunk, of all the common textures. (*Anat. Plantar.* p. 139.) By Willdenow, it is regarded as an abortive leaf, being simply a prolongation of the petiole, without the leafy expansion. (*Principles of Botany*, p. 272.) Its form, as it occurs in the Vine, is exhibited in the upper portion of fig. 22. $h'$, Plate XVII.; but, in this particular, it is subject to the greatest variation.

308. The leaf itself, as well as the petiole, is said to be sometimes prolonged into a tortuous appendage resembling the tendril; and similar transformations are sometimes exhibited by the peduncle and petals of the flower. In one species of Vine, mentioned by Malpighi, the extremity of the tendril, which is at first pointed, becomes gradually incurvated and reflected, and at length is formed into a roundish body, which is furnished with small papillæ, that yield a viscous fluid, by means of which it attaches itself to walls or wood, so strongly as not to be easily separated. In Dodder (*cuscuta*), small tubercles are formed on the stem, which, according

Of Roots. to M. Decandolle, are so organized as to fix themselves on any other plant, and derive nourishment from it. (*Théorie Elément. de la Bot.* p. 344.) For descriptions of the several varieties of these organs enumerated by botanists, and for the terms employed to express them, we must refer to their works.

### Section III.

*Of the Structure of Roots.*

Varieties of Roots. 309. Roots possess very different forms, to which botanists have assigned distinct appellations. Some, as those of trees, branch out from one trunk beneath the soil, and are named *branched* roots; other plants have a number of equally sized roots collected into a bundle, and are called *fasciculate*, or sometimes *fibrous*. In other instances, the root is spindle-shaped, *fusiform*; or shaped like the hand, *palmate*; or composed of many joints, *articulate*. In the course of the root, knobs or tubers are sometimes found, giving to such roots the name of *tuberous*; in others, a fleshy bulb occurs, and such are called *bulbous*; others run horizontally beneath the soil, and are named *creeping*; and others are abruptly terminated, or as if bitten off, and called *præmorse*. For examples of these and many other varieties, we must refer to the writers on botany.

Parts of Roots. 310. The root (*radix*) of the mature plant, is held to consist of two parts; the stock or main body (*caudex*), and the ramified productions called radicles or rootlets. These parts are generally concealed beneath the soil; but, in the case of parasitic plants, they are inserted into other vegetables. Some of the lower tribes of vegetables have their roots attached to stones, and rocks; and the roots of others have no fixed attachment, but float loosely on water. The different species of *Tremella* have no root at all; but the functions of this part are performed by the general surface. With regard to duration, some roots speedily decay; others continue permanent. The varieties in their figure have been noticed in the enumeration of their names, and the direction they pursue in their growth, is either horizontal or perpendicular, or in some intermediate position.

Roots of Trees. 311. With respect to structure, the body of the root of *trees*, says Malpighi (*Anat. Plantar.* p. 145.), may be regarded as a production and elongation of the trunk beneath the soil; and is constructed of the same textures, disposed nearly in the same manner; wherefore it is unnecessary to detail them at any great length. Exteriorly is placed the cuticle, beneath which is the cellular tissue of the bark, with its accompanying cortical layers, the vessels of which have a reticulated form. The bark is thick; its vessels frequently contain the same "proper juices" as those of the trunk, and its cells are alike filled, in some roots, with concreted matter. From the bark to the centre, the two orders of transverse septa are observed to proceed; and are interposed between the rays of vessels, as in the trunk. These vessels, in the root, are often larger than those of the trunk; and instead of a pith, the central part of the root is commonly occupied by vessels. The primary rootlets, which spring from the principal stock, are often tortuous, and are propagated in several successive series, like the branches and ramulets of the trunk; from them proceed still finer ramifications (*capillamenta*), which are the true absorbents of the root, and may be termed capillary rootlets, as they are sometimes named by Du Hamel.



Roots of Herbs; their Skin; 312. In various *herbaceous plants*, the root has been particularly examined by Grew. (*Anat. of Plants*, Book II.) Its skin is of very different colour and thickness. In the early state, it is represented as an extension of that which covered the radicle of the seed; but in more aged plants, the exterior covering is derived from the cellular tissue of the bark. It is usually, if not always, compounded of vessels and cellular tissue; both of which are distinguishable in many roots.

their Bark; 313. Beneath the skin, the cortical texture is observed, making up, in some herbs, the greater portion of the root, while in trees it is commonly thin. It is composed of cellular tissue and fasciculi of vessels variously dispersed through it, and forming a network, the meshes of which are filled with the tissue. In these vessels, various gummy, resinous, and milky liquors, similar to those in the bark of the stem, are frequently contained; and it is by their presence that the *position* of the vessels is best distinguished. Very frequently they make a ring at the inner edge of the bark, "in which place and position," says Grew, "they stand in most, if not all roots, how variously soever they are posited also otherwise." They occur, however, in clusters in the bark of many roots, and in others are disposed in rays, or seen sometimes to be irregularly dispersed through the cellular tissue in common with the sap-vessels. The cells of this tissue sometimes preserve nearly an uniform size; in other instances they are of very irregular forms; and frequently are compressed into transverse septa, which everywhere intercept the vessels, and are of very various size and number; they are the receptacles of liquor, but are often found empty.

their Wood; 314. The woody part in herbaceous roots is described as consisting of vessels and cellular tissue; this tissue forms sometimes transverse septa, but in some roots it is disposed in rings. The vessels are disposed either in separate fasciculi, or in rays, or rings. In number and size they very much vary in different roots, and also in the same root; they generally appear empty, but may sometimes contain sap; they frequently occupy the centre of the root to the exclusion of pith; but near the top of the root, a pith is often to be found.

315. Having given this general description of the structure of roots, we shall now exhibit a few examples of it. In the young state of the herb, this structure has been already displayed in sections of the pea and gourd, figures 12. 13. and 17. Plate XVI. In the root of the Gourd, at a later period, M. Kieser delineates four large fasciculi of vessels, each of which contains between thirty and forty vessels; the larger vessels are situated near to the circumference, and the smaller ones towards the centre of the root; they all exhibit the *spiral* character, and many of them are obstructed by vesicles. (*Mém. sur l'Organisat. des Plantes*, Planche X.)

316. In fig. 13. Plate XVII. is a transverse sec-

Of Roots.

Root of Asparagus.

tion of the root of Asparagus, copied from Grew, but on too small a scale to show more than the relative position of the parts; the letter $r'$ denotes the bark, at the inner margin of which the proper vessels are placed in a ring; $s'$, the sap-vessels or woody part placed more interiorly; and $t'$, the pith at the centre. A very highly magnified representation of this root is given by Grew in table 10. of his work. If his view of its structure be correct, it exhibits a remarkable difference in the arrangement of parts in the stem and root; for the stem of Asparagus is one of those in which neither distinct bark, nor wood, nor pith, exists; but the cortical and ligneous textures are blended together.

Root of Mallow.

317. In the root of Mallow, the position of the vessels is quite different, as exhibited in fig 14., in which the letter $v$ denotes clusters of proper vessels, postured in a radiated form in the cellular tissue of the bark; within these rays is a portion of cellular tissue, through which a few sap-vessels are dispersed; but they are chiefly accumulated at the centre $(w)$ of the stem. In several of Grew's tables, transverse sections of various other herbs are given, which display the greatest possible variety, in the proportion and arrangement of the vascular systems of the bark and wood; to them we must refer the reader who may desire farther information.

Of the Vine.

318. In shrubs, the arrangement of the parts of the root is commonly more distinct than in herbs, and corresponds with that in the trunk. In the transverse section of the root of the Vine, fig. 15. the letter $x'$ denotes the place of the "proper vessels," situated in the cellular tissue of the bark; $y'$, the sap-vessels extending in radii to the centre of the root, which is altogether destitute of pith; and $z'$ marks the transverse septa which are interposed between the rays of vessels. Of this figure a very highly magnified view is also given by Grew in table 17. of his work. In table 16. the same author represents the structure of the root of Wormwood. His delineation of it is copied in Plate CCCCXX. (Article Plant) in the body of this work, to which we refer the reader. The disposition of the parts resembles almost exactly that of the Vine, except that the "proper," or "balsam vessels," as he calls them, are placed at greater distances from each other; and, from containing a viscid fluid, are enlarged, and rendered more distinct.

Origins of Rootlets,

319. We before noticed the manner in which the rootlets were given off from the radicle in the Pea and the Gourd. All parts of the root possess the power of emitting rootlets when they are placed in favourable circumstances; and this power is possessed also by the branch. If the branch of many trees be cut off and planted in the earth, it emits rootlets from its sides beneath the soil, and becomes at length an entire plant, possessing the several members of root, trunk, and branches. If even the bark of a branch be partially removed, so as to intercept the course of the *descending* sap, and the detached part be, at the same time, surrounded with moist earth in the manner of a graft, the upper portion of the divided bark will emit rootlets into the earth; and if, after a certain period, the branch be separated and planted, it will form a tree, sooner, it is said, than by most other methods. The simple immersion of the cutting of some trees in water, as of the Willow, is sufficient to elicit the production of rootlets. The origin of these has been traced by Malpighi (*Anat. Plantar.* p. 146.), and is exhibited in fig. 16. Plate XVII.; in which is represented a longitudinal section of the cutting of the willow, and of the rootlets it emits from its sides. These rootlets spring from the cutting, just at the surface of the water, not below it. They appear, at first, like small tumours in the bark, which protrude and gradually force their way through it, forming fissures, which are, as it were, bordered by a lip, and afford passage to the springing rootlets. In the figure just referred to, $a$ denotes the outer portion of the bark that forms the lip; $b$, the inner portion which protects the springing rootlet; $ccc$, three rootlets which are seen to originate from the perpendicular vessels of the wood.

in the Willow.

Structure of Rootlets.

320. The capillary rootlets which thus spring from the larger roots, and from branches, are much more simple in structure than buds, being made up chiefly of the ligneous texture of the trunk, which, in shooting, carries with it a portion of the cortical texture that covers it. They are the organs which absorb nutriment from the earth, and convey it into the larger rootlets, by which it is transmitted to the trunk. Hence, as Du Hamel observed, the earth is exhausted of its nutrient matter, chiefly where these capillary rootlets are distributed, and not in the neighbourhood of the larger roots. On examining the roots of trees, after a severe winter, he found these capillary rootlets to be generally dead, which led him to suspect that trees lose, in the earth, their rootlets, as, in the air, they lose their leaves. He found, that, even after slight frosts, during every period of winter, many of these capillary rootlets were destroyed; and that, when the temperature became milder, new rootlets were developed, which abundantly replaced the others. (*Phys. des Arbres*, Tom. I. p. 88, 89.)

Rootlets annually renewed.

321. Analogous to the production of rootlets from the branches, when the descending sap is intercepted, is that of the emanation of similar organs from the knots in the stems of many plants, as those of the *Gramineæ*. Wherever a knot of this description is brought into contact with the moist earth, numerous rootlets break out, and buds also, from which entire plants are produced. In the culture of the Sugar-cane, the propagation of the plant is continued entirely in this way, and never by means of seed; in the several modes of engrafting, and various other horticultural operations, the cultivation of vegetables proceeds on a similar principle; for the graft, which is attached to and becomes rooted in another tree, may, by a different method, be made, like the cuttings of willow, to furnish roots from its own substance.

Tuberous Roots.

322. In some plants, as *filipendula*, the roots and rootlets swell out into globular bodies, or tubers of the shape of olives: these tubers are composed of vessels with a large portion of cellular tissue, and from them other rootlets spring. In other instances, the tuber that forms on the root is a true bud, which acquires a large size, and from it the real rootlets,

Of Roots ‖ Of Buds.

possessing a filiform figure, also spring. (*Malpighi, Anat. Plantar.* p. 150.) The bulbs attached to the roots of many plants are likewise to be regarded as real buds, and will be briefly noticed in the next section.

Effects of Soil on Roots.

323. M. Du Hamel has made many observations and experiments on the effects of the soil in determining the form of the root. All roots that spring from seeds have, according to him, a spindle shape, if they are made to grow in soil that is easily penetrable. He has seen the root of a young Oak extend in such a soil to the depth of four feet in the form of a tap-root, when the stem possessed only six inches in height. If, however, at a small distance from the surface, it meet with obstacles, which oppose its descent, it then continues short, and divides into lateral branches. A similar production of lateral branches is observed, if, by any accident, the leading trunks of the root be destroyed.

If, on the contrary, a trench be dug in the neighbourhood of a root, and then filled up with fresh earth, the root will extend through the soft earth, without producing lateral branches; and the same often is observed to occur in very moist situations. The direction of roots is also greatly varied by the qualities of the soil, for they extend into that which is richest, while the barren parts are nearly destitute of roots. (*Phys. des Arbres*, Tom. I. p. 82.) So great, indeed, appears to be the influence which the qualities and texture of the soil exert on the growth of roots, that in many instances, before we could pronounce on the true form of a root, it would be necessary to define the kind and condition of soil that is most natural to it.

## CHAP. III.

### THE ANATOMY OF THE ORGANS OF VEGETABLES.

### SECTION I.

#### *Of the Structure of Buds.*

Buds.

324. In the preceding chapter we have described the larger and more permanent members of the plant, which produce and sustain all the other organs: we have now to delineate the form and structure of these organs, which have a more temporary existence, and present a more diversified character. They may all be said, either directly or indirectly, to originate from buds, with which therefore we shall commence our descriptions.

Definition.

325. A bud, according to Gærtner, is an organic body, sprouting from the surface of a plant. In the beginning, it is distinct from the proper and permanent members of the plant, but after some time becomes a part of it; or, if separated, is capable, by the increase of its own proper substance, of growing into a new plant, perfectly similar to its parent. (*De Fructib. Plantar.* p. 3.)

326. Buds may, in general, be easily distinguished from seeds; but in some of the lower tribes of vegetables, the conformity in external appearance and internal structure is said to be so great, as to render this a matter of much difficulty. This appears to arise principally from the extreme minuteness of the organs of reproduction in those plants, and the consequent uncertainty in discriminating their true character; so that botanists are not agreed as to what, properly speaking, should be termed a bud, or what may be deemed a seed; some choosing to regard as a bulb or bud what others denominate a seed.

Species of Buds. Propago.

327. Gærtner enumerates four species of buds, two of which are leafless, and two are provided with leaves or scales. The first, *propago*, is the most simple species of bud; it is leafless, and possesses different forms; sometimes it is entirely naked, and sometimes is enclosed in a bark-like case; it at length separates spontaneously from its parent, and is dispersed like a seed.

Gongylus.

328. The second species is termed *gongylus:* it is described as a perfectly simple, leafless, somewhat globular and solid bud, concealed within the bark of the parent plant, and never separating spontaneously, till the bark decays by age. It has a great affinity to the tuber of roots, but differs from it in not being a proper member of the plant, and in not possessing the principle of multiplication which resides in the tuber.

Bulbus.

329. The third species of bud is a compound germen, and named *bulbus*. Its figure is somewhat globular; it is nearly leafless, and formed of a very short keel (*carina*) and thick succulent scales, and at length separates spontaneously from its parent. Of this species there are two varieties, the one *solid*, constructed of a solid fleshy body, and having generally the rudiments of the new plant fixed outwardly upon it; the other *coated*, being formed of several concentric scales, in the centre of which the young plant is cherished.

Gemma.

330. The last species of bud, and that which is strictly so named, he denominates *gemma*. This is a bud composed of a subulate keel, and distinct herbaceous leaflets; it resembles a branch in miniature, and never separates spontaneously from its parent. It is named an *eye* (*oculus*) when it puts forth flowers alone, or flowers and leaves together; and simply a *gem* (*gemma*) when it is unfolded into leaves alone.

331. Of these several species, the last, *gemma*, is generally considered as alone entitled to the appellation of a true-bud, by those who consider scales and leaves as essential to its constitution; but this definition, says Gærtner, would exclude even bulbs, and it is better to derive our idea of a bud from a general agreement in properties, and particularly from similarity of origin in formation and evolution, than from the ever-varying condition of external form. The two former species of buds occur in the lower tribes of vegetables; the two latter are observed on the stems and branches, and roots of various plants. On the present occasion, we shall notice the latter only.

Structure of Bulbs.

332. That variety of bud which is called a *bulb*, and which springs from, or is variously attached to, the roots of many plants, has already been stated to exhibit considerable difference in structure. It is sometimes constructed of several thick scales or leaves enveloping each other, and is sometimes formed of a more continuous and solid substance. To the first description belongs the bulbous substance of the lily and tulip. Grew has given a section of the lat-

Of Buds.

ter, made in the month of September. It displays the tunicated structure of the bulb, at the base and in the centre of which, the young flower, destined to appear in the following spring, is observed. See his *Anatomy of Plants*, tab. 63., or Plate CCCCXXI. fig. 17., in the body of this work, accompanying the article PLANT. Of the tunicated variety, the common onion affords also a good example. The coats that compose its bulb, are to be regarded as fleshy leaves, and the true root, according to Du Hamel, is the fleshy plate that supports the bulb, from which the rootlets spring. The common potatoe affords an example of the solid bulb, on whose surface numerous buds, all capable of producing entire plants, are seen. Botanists enumerate a great many other varieties of bulbs, for which we must refer to their writings; and to the works of Malpighi and Du Hamel for the anatomy of many of them.

Names of Branch-buds.

333. The true bud of the stem and branch was distinguished by the ancients into two kinds, according as it produced either a leaf or a flower, and to it they assigned different names. "*Germen autem est id quod ex ipsis arborum surculis primo vere exit, ex quo deinde folium producitur*," says Pliny; and this he distinguishes from the flower-bud, "*nam gemma propriè floris est*." By Grew, the term *germen*, and by Malpighi, the word *gemma*, is employed to denote each variety of bud. By Linnæus, the term *germen* is used to denote, not the bud of a branch, but the rudiment of a seed; and not the rudiment of the seed only, but the organ also that contains it. The word *gemma* he uses to denote a bud. Gærtner adopts the word *germen* in a generic sense, to express every species of bud, and with Malpighi and Linnæus, employs the term *gemma* as indicative of that species now under consideration. This, therefore, as the most generally received appellation, we shall in future employ.

Description.

334. During summer, says Du Hamel, buds are gradually formed in the axils of the leaves, viz. in the angle which the petiole forms with the branch. They are at first exceedingly minute; are seen in winter chiefly on the young branches, sometimes on the larger ones; and more rarely on the trunk. They exhibit different forms, according to the kind of tree that bears them, and are attached to it by a very short pedicle. Their position on the branch was considered by M. Bonnet to be reducible to five classes; sometimes they are situated on opposite sides of the branch, but placed alternately, and sometimes they are placed exactly opposite to each other. In other instances, they form a kind of ring round the branch. Sometimes they have a spiral disposition; and at others constitute a sort of double spiral around the branch. In those cases, where the buds stand opposite on the branch, the extremity of the branch is frequently terminated by three buds; but where the buds are only alternate, the young branch is commonly terminated by a single bud. In the Pine, the true buds are placed, not in the axils of the leaves, but at the extremity of the branch alone. Some buds stand out a considerable distance from the branch; others are placed in close contact with it; and these varieties occur sometimes on the same branch in regard to the buds that issue from its sides and extremity. The shape of buds is also very various—some being long and pointed, others short and round; some again are hairy, others smooth; some very small, and others large. (*Phys. des Arbres*, Tom. I. p. 99.)

Leaf and Flower-buds.

335. Beside these varieties in position and form, which serve to distinguish the buds of different genera and species, there are also many sorts of buds to be observed on the same tree, whose characters are discoverable by their form. Those which are pointed, usually produce leaves and branches; and from those which are large and rounder, commonly proceed flowers. The former are named leaf or wood buds (*gemmæ foliiferæ*); the latter flower or fruit buds (*gemmæ floriferæ*); others, which possess both leaves and flowers, have been called mixed buds (*gemmæ mixtæ*.) In some trees, as those of Apple and Pear, two varieties of wood-buds occur, one of which is small, produces only a small bunch of leaves, and in the end becomes a fruit-bud; the other is larger, and gives origin to a branch.

Formation of Buds.

336. As the rudiments of the flower appear in the bulb of roots, the season before they are destined to bloom, so those of the leaf and the flower are distinguishable, at the same period, in the bud of the branch. They are to be perceived, says Du Hamel, in autumn, and continue to grow even during winter, appearing to be clandestinely formed in that season, when the movements of the sap seem to be suspended; and are thus prepared to shoot forth on the return of spring. It is, however, only in perennial plants that these phenomena are observed. Annual plants do not produce buds, and even those whose roots survive the fall of the stem, produce buds only on their roots. (*Phys. des Arbres*, Tom I. p. 103.)

Effects of Climate on Buds.

337. Climate appears to exert the greatest influence on the formation and evolution of buds. In cold regions, as we have just observed, the bud is formed many months before it is destined to shoot into a leaf or branch; but in warmer regions, scarcely any interval occurs between the periods of formation and evolution. The buds in such climates, are said to unfold themselves immediately from the bark into branches, without having remained, in the form of buds, for any length of time. Sometimes, in the milder seasons of our own climate, the evolution of buds rapidly succeeds to their formation, and the vegetative process with us, emulates the productive powers of more favoured climes. In some examples, however, the specific characters of particular plants overcome these general tendencies of climate; and thus hot climates are said to possess some bud-bearing plants, and in colder climates, there are a few shrubs which are said never to bud. (*Willdenow's Princip. Botany*, p. 273.) It seems, however, more correct, to consider all plants as bearing buds, from which the branches, the leaves, and the flowers, successively proceed; and to say that in warm climates in general, no suspension of the vegetative process occurs as in cold ones; and no marked interval is observed therefore between the formation and evolution of buds. The few exceptions that occur respectively in warm and cold climates, must be considered in reference to the specific characters of the individual plants. The process by which buds are

Of Buds. actually formed, has been called *Gemmation* or *Gemmification*.

Parts of Buds. 338. Having made these few general remarks on the nature and formation of buds, we have next to exhibit a few examples of their structure and evolution, confining ourselves at present to a description of those which produce either branches or leaves. The mature bud consists of two parts—one that forms the new branch or leaf, and in the language of botanists may be termed *persistent*—the other serving only a temporary purpose, and falling when that purpose is accomplished. To the former may properly be applied the term *germ* or *gem*, and the latter, from its office, may be called *hybernaculum*. In its leading characters, the bud bears a near analogy to the more perfect seed; for the germ very exactly resembles the plume; and the hybernaculum, as we shall see, in structure, office, and duration, approaches near to certain cotyledons.

Hybernaculum. 339. The leaves or scales which constitute the *hybernaculum*, and which, in future, we shall denominate the *hybernacular leaves*, vary much in number, size, and figure, in different buds. Even in the same bud, the inner ones are thinner, and much more tender and succulent than the outer, and are besmeared with a viscid humour which intimately unites them; while the outer ones are commonly hard, hairy, and of a scaly texture. Like the cotyledonous leaves of seeds, those of the hybernacle sometimes grow for a certain time with the germ, and fall successively, at periods more or less distant: they are also not less distinct in figure from those of the germ, than the leaves of the cotyledon are from those of the plume. This arises from the peculiarity in the distribution of their vessels, which do not spring from one common central trunk, as in ordinary leaves, but are derived from several distinct fasciculi at the base, like those of the cotyledonous leaf, as seen in that of the Gourd, Plate XVI. fig. 11. According to the manner in which they are disposed or folded up in the bud, botanists have assigned them different names, for an account of which we must refer to their writings. In the opinion of Du Hamel, they all derive their origin from the inner layer of the bark, of which they seem to be only a prolongation. (*Phys. des Arb.* Tom. I. p. 103.)

Germ. 340. The *germ* of the bud, which is contained within and protected by these enveloping leaves, is composed of one or more leaves generally folded and curled; but in some instances open and expanded. At first they are very small, and their form is indistinct, so that the pedicle alone is distinctly visible, from which branch off the vessels that form the middle rib, and are afterwards expanded to construct the lobes of the leaf. From the figure, which the germ possesses before its expansion, being like that of a keel, its vascular portion, at this period, has been named *carina*, and its softer part *medulla* or pith.

Origin of the Germ. 341. With respect to the particular portion of the branch, from which the germ internally derives its origin, opinions have much varied. Some have held that it proceeded from the pith alone; others from the first circle of vessels that immediately surrounds the pith; others from the tender wood alone; and others from the pith, the wood, and the bark conjointly. Grew held this latter opinion. (*Anat. of Plants*, p. 28.) Malpighi describes the germ as a tender ligneous substance, formed of vessels and cellular tissue, and surrounded by its proper cortical texture. (*Anat. Plantar.* p. 45.) According to Du Hamel, it originates from the ligneous texture and the pith (*Phys. des Arbres*, Tom. I. p. 103.); and Hill considered it to spring from the first circle of vessels alone, but not to carry with it any portion of the pith.

342. As every germ is composed of the cortical and ligneous textures, it may be said to originate in part from both, as all these writers seem to admit. Sometimes also the pith of the germ is continuous with that of the branch; but, in other instances, no such connection subsists, and there is nothing in the character of the pith of the trunk that renders it at all essential to the constitution of the germ. That, in many instances also, the germ springs from the first circle of vessels, is most certain; but it is not less certain that buds spring from trees long after this first circle of vessels has lost its vegetative power, or has been entirely destroyed. The view already given of the origin of rootlets from a branch, fig. 16. Plate XVII. seems very nearly to represent that of a bud, the latter possessing only a larger portion of cellular tissue in the composition of its bark and pith.

Bud of the Oak. 343. In the oak, Malpighi describes the entire bud as consisting of many scales enveloping each other, and forming an oval body. When evolution commences, these open and expand, and in part fall; but two generally remain and protect the springing germ for a long time. In fig. 17. Plate XVII. is represented one of the hybernacular leaves ($d$) of the Oak-bud, at the base of which the germ ($e$) is placed. The leaf ($d$) is described as possessing an oblong form, and is very evidently vascular; the germ is exceedingly small, and is represented as possessing at this period only one fasciculus of vessels. By degrees, three fasciculi become apparent, which are continued through the germ, and form three pointed extremities, as in fig. 18. A. These parts augment, and the vascular fasciculi separate, so as to produce successively the appearance in fig. 18. B. and in fig. 19. ($f$.) At length, the small curled leaf ($i$) rising between the two hybernacular leaves $hh$, fig. 20. is seen to resemble the plume of the seed, and to possess a form altogether different from the enveloping leaves, which, in appearance, resemble more the cotyledonous leaves of certain seeds. In fig. 21. is given a vertical section of the germ considerably magnified, in which $k$ denotes the pith that occupies the centre of its pedicle; it is enclosed by vascular fasciculi ($l$) that send off through the bark ($m$) ramifications to the several little processes that compose the serrated border of the leaf. (*Anat. Plantar.* p. 41. 45.)

Other Buds. 344. But the method of nature, in the evolution of buds, continues Malpighi, is not always the same; for the hybernacular leaves do not always waste and fall as those of the germ increase. On the contrary, in many trees, these leaves, especially those about the base of the bud, losing their primary figure,

Of Buds.

assume new forms, and are converted into the permanent leaves, with which the branch is adorned. Examples of this sort occur in Laurel, in the Apple, the Almond-tree, and many others. In other instances, as in the Rose, the permanent leaves seem to be generated out of those of the hybernacle, from the apex of which they emerge; and gradually the latter is changed into a sort of petiole, to the sides of which two slender appendages, the remains of the former hybernacular leaf, adhere. (*Ibid.* p. 41.) Similar transformations are said to occur in many other plants.

Buds on the ends of Branches.

345. The buds, such as they have been described, pullulate variously from the sides of stems and branches, and always above the insertion of the fallen leaves; but they spring also from their extremities, and produce the annual elongation of the branch or stem. The manner in which this takes place, and the appearance which the parts exhibit, have been well illustrated by the observations and dissections of M. Du Hamel. In the evolution of the seed, the plume, as we have seen, rises above the earth, and produces the stem which puts forth leaves. When these leaves fall in autumn, the stem continues, and is terminated by one or more buds. The roots, as already remarked (238.), do not increase in length, but at their extremity, and therefore never elongate, after the smallest portion of their extremity has been cut off. It is not the same with branches; for the newly formed part of the young shoot actually elongates, especially at its extremity, where it is most succulent and tender; less in the parts lower down where it is harder; and in its more ligneous parts not at all—as Du Hamel, by very simple and decisive experiments, ascertained. (*Phys. des Arbres*, Tom. II. p. 14.)

In Horse-Chesnut.

346. The appearance, structure, and evolution of a bud, at the extremity of a branch of the Horse-chesnut-tree, are given by the same ingenious author, whose candour, ability, and success in the prosecution of these curious researches, render him worthy to rank by the side of Malpighi and Grew. In fig. 1. Plate XVIII. is represented part of the annual shoot of this tree, terminated by its appropriate bud, formed in autumn, and which is the commencement of the next year's shoot. In fig. 2. a vertical section of the same bud is exhibited, in which the number and disposition of the hybernacular leaves that envelope and protect the germ in the centre are displayed. In the stem of the shoot, the letter *a* denotes the pith, which is surrounded by the wood *bb*, and this again is covered by the bark *cc*. In fig. 3. is represented a section of part of the bud, detached from the woody part of the shoot, and a little magnified, to show that the leaves of the *hybernaculum* take their origin from the inner portion of the bark.

Their Structure.

347. Proceeding next to the interior part of the bud, Du Hamel represents it as composed of numerous small leaves (fig. 4.), which are more and more minute as we proceed inward, and are covered with fine hairs. In fig. 5. is a branch-bud of the Peach, as seen in February, after all the enveloping scales have been removed. It is composed of greenish filaments, ranged nearly as they appear in the figure. When some of these filaments were detached, and viewed with the microscope, they appeared toothed at the edges, as in fig. 6., and were covered with hairs. All these filaments were afterwards detached, in order to disclose a small body lodged within them, and which appeared to consist of two small leaflets, folded and toothed at their edges, but not covered with hairs. It is represented in fig. 7. It occupied the centre of the shoot, and seemed to be connected with the pith.

348. In the next figure 8. is represented the bud of the Horse-chesnut, in the state of evolution. The letters *dd* indicate the scales of the hybernaculum thrust aside by the shooting of the germ *e*, accompanied by two permanent leaves *ff*. The letter *g* denotes the place of a second bud. A vertical section of the same bud is shown in fig. 9., from which all the scaly envelopes have been removed. It exhibits an entire shoot of one year's growth, attached to part of one of two years. From *h* to *i* denotes the growth of two years; and from *i* to *k* that of one year, with the germ *k* in the centre and the lateral leaves, as in the preceding figure. The letter *l* marks the pith, *mm* the wood, and *nn* the bark of the young branch. From *l* to *n*, the pith is white; from *n* to *o*, greenish; and towards *i*, it is of a brownish red colour. From *i* to *k*, which marks the extent of the annual shoot, the pith is green and succulent; and at *pp*, it is seen to be prolonged into the lateral branches. The wood of two years' growth, from *m* to *i*, is white, and forms a continuous tube round the pith, except where the branches go off. It is covered by another layer so thin as to be scarcely visible, but which will, in the end, become wood; and this layer is covered by the bark. The ligneous layer of the annual shoot appears to be a prolongation of the new layer of the older one, and, like it, possesses at first an herbaceous character. The cortical layer also seems to be a prolongation of that of the older shoot. As to the pith, though in both shoots it is continuous, it is to be observed, that that of the older branch is white and dry, and that of the young shoot green and succulent. (*Phys. des Arbres*, Tom. I. p. 117.)

Elongation of Branches,

349. It is thus by the formation of a bud in autumn at the extremity of a branch, and the shooting and growth of that bud in the succeeding spring and summer, that the trunk of the tree and its branches are annually elongated. During the first season, the shoot retains, in great part, its herbaceous characters; but, in the second, it becomes perfectly ligneous. In the axils of the permanent leaves of the young shoot, the rudiments of new buds become apparent, even in the first season.

as displayed by Du Hamel.

350. It was before remarked, that trees receive an additional circular layer every year, and that from these new layers buds successively spring, so that the earliest branches may contain as many ligneous layers as the trunk, and those of later formation a smaller number, according to the year in which they shot forth, and the circle of wood from which they sprang. Combining this growth in breadth with that in length, it will appear, says Du Hamel, that at the base and centre of a tree 100 years old, there is wood of 100 years of age; whilst, at the exterior part of the same tree, and at the extremities of its branches,

Of Buds ‖ Of Leaves.

there is wood of one year's age only. As the latitudinal growth was before illustrated by a diagram, a similar mode may be adopted to explain the longitudinal increase.

351. Let figure 10. Plate XVIII. represent in *q r* the ligneous portion of a tree that has proceeded from a seed in spring, and is observed in autumn. The following spring, a second shoot proceeds from the bud *r*, which reaches as far as *s*; but, at the same time, there is a second ligneous layer formed on the first shoot *q r*, by which its thickness is proportionally augmented; and, at the end of the second year, the tree has the form and extent of the unshaded portion of the figure *q s*. The next spring, the bud (*s*) opens and sends out another shoot to *t;* and ligneous layers are added as before to the two preceding shoots; and thus the tree is extended from *q* to *t*. The fourth year the same processes are repeated, and the tree extends from *q* to *w;* and each annual shoot, from the base to the summit of the figure, is seen to be composed successively of four, three, two, and last of one layer in thickness. This figure, therefore, illustrates the mode in which trees increase at the same time in height and breadth. The ligneous layers may be compared to a series of cones which envelope each other, and which annually augment the diameter of the tree by the two thicknesses of the layers. It shows also that trees grow much more in height than in breadth, and that this growth is effected by the successive formation and evolution of buds at the extremity of the stem, precisely as the first shoot issues from the seed. (*Phys. des Arbres*, Tom. II. p. 50.)

### Section II.

#### *Of the Structure of Leaves.*

Leaves.

352. These are organs of great importance in the vegetable economy; they are not, however, universal, for the *Cactus*, some species of *Schœnus*, and a few other plants, are considered to be destitute of leaves. Like other parts of the plant, they may be regarded with reference either to their external form, or their internal structure. The former view belongs more especially to the botanist, who has very happily applied his descriptive language to pourtray the almost infinite diversity of figure, size, and character, which the leaves of different species of vegetables exhibit. On this branch of the subject we shall but lightly touch, recalling simply to notice the more leading distinctions of the botanist, and such only of them as may appear to be more immediately connected with the *structure* of these organs.

Description.

353. The leaves *(folia)* are distinguished and denominated according as they are *simple* or *compound*. Simple leaves are such as have only a single leaf on the stalk or petiole that supports them, and where all the parts of the leaf are continuous with one another. Compound leaves are those which are made up of more than one piece, or where the leaf is formed of parts or leaflets articulated together. In regard to their place, situation, and insertion, leaves are said to be *determinate*. By the *place* of a leaf, is meant the part of the plant to which it is attached. By *situation*, is understood the disposition of the leaves on the stem or branch, which corresponds to that of the buds. By *insertion*, is expressed the mode of connection between the leaf and the stem or branch; and the *direction* of leaves is considered to bear reference to the position in which they stand to the stem.

Of Leaves.

Parts of Leaves.

354. The foregoing observations apply to leaves considered in connection with other members; when we regard them singly, we remark several parts which are common to almost all leaves, and to which particular names have been assigned. The part at which the leaf springs from the branch or stem, whether directly or by means of a petiole, is called the *base*, and the point opposed to this, the *apex* of the leaf. Each leaf has also two sides, faces or surfaces, as they are indifferently called. The prominent lines that appear on these surfaces were named riblets (*costulæ*) by Malpighi, and have very improperly been called *nerves* by most writers; for the term nerve denotes an organ of a totally different nature, of which not even the existence has yet been demonstrated in any part of the vegetable system. To the line that circumscribes and forms the boundary of the leaf, the term *margin* is commonly applied.

Their Characters.

355. The *figure* of leaves exhibits the greatest diversity, to express which various terms are employed; their *margin* also is either entire or variously fissured, notched, or toothed; their *surfaces* are naked and smooth, or clothed with hairs, and studded with excrescences; sometimes they are plain and flat, at others furrowed or plaited; and in all these particulars, the opposite surfaces present also the greatest diversity. In size, leaves exhibit the most remarkable differences; and, with respect to *substance*, some are exceedingly thin, and have a membranous texture, others very thick, and of a fleshy nature. As to colour, they exhibit every shade of green, from the most gay and lively, to the deepest and most obscure. In some, the tint of colour approaches to blue; in others to red; and previous to their fall, they all undergo those changes of colour which produce the diversified beauties of an autumnal scene. The period, however, at which this occurs, is very different. Some leaves fall early, before the summer has passed, and are termed *caducous;* others retain their place till autumn, and then fall, and are named *deciduous;* others continue beyond the summer, and are styled *persistent;* and others, which have a still longer duration, are denominated *perennial.*

Origin from Buds.

356. In the preceding section on the structure of buds, we exhibited the form and appearance of leaves in the earlier periods of their existence. They were shown to possess a very minute size, and to be curiously folded up, and concealed within their various scales or coverings, which effectually protected them from the rigour of the winter season. The germ of the bud, from which the leaves originate, was stated to be composed of the same elementary parts as the stem and branch from which it sprang. From the ligneous ring in the annual shoot, it derived its vessels, which, after having traversed obliquely the cortical layers, were prolonged into the pedicle by which it remained attached to the branch. This pedicle

Of Leaves. was shown to consist of a pith, encircled by vessels, which branched off through the cortical texture, to form the keel of the germ in its folded state; and, in its more expanded forms, to constitute the vascular riblets of the leaf. By subsequent growth, this gradually extends and elongates, becomes more ligneous, and is formed, at length, into the slender stalk or petiole, by which the leaf remains attached to the branch. (*Phys. des Arbres*, Tom. I. p. 123.)

Structure of the Petiole. 357. The vessels, which are given off from the branch to form the petiole, are not collected into one bundle, but constitute several fasciculi, which are disposed, in different ways, about the centre of the stalk. In some stalks there are three, in others five or six, and in others seven or more fasciculi, all placed, says Grew, either in an angular or circular posture, and at a greater or less distance from the centre. This centre is generally occupied by a pith, but sometimes it is hollow or tubular. In table 49. of the *Anatomy of Plants*, several transverse sections of the petioles of the leaves of different plants are given, exhibiting the different modes in which these fasciculi are dispersed through the cellular tissue that forms the greater portion of the stalk. In every instance, the pith and bark of these petioles are represented as forming one continuous substance. In some plants, the fasciculi of vessels that come off from the stem are not collected into a cylindrical figure, but, after being variously implicated with each other, expand at once into a leaf. Such leaves rise by a broad base, and, from being destitute of a petiole, are termed *sessile*, forming often a sort of sheath about the stem, of which several varieties are enumerated by botanists.

358. The petiole, as it springs from the branch, may be compared to a small stem, which, at the basis of the leaf, expands into numerous branches. Frequently, it is continued through the centre of the leaf, forming its middle rib, and giving off, in its course, numerous branches. At other times, on reaching the base of the leaf, it separates at once into three or more equal portions, which form as many distinct leaves or parts of a leaf, supported by their respective petioles. The structure of the petiole is the same as that of the branch, being composed of the ligneous and cortical textures, in which sap and proper vessels are discoverable, and the whole is invested by the cuticle.

Of the Leaf. 359. Where the petiole terminates, the proper or expanded portion of the leaf commences, the figure of which is determined by the number and distribution of the vessels. These vessels divide and ramify in various modes, till at their termination they form a finely reticulated structure. In many recent leaves this structure is very visible, but when the softer parts are removed by spontaneous decomposition, the vascular system of the leaf remains nearly entire, and its extent and form are then more completely exposed. In fig. 11. Plate XVIII. this distribution of the vessels is exhibited in a leaf of Holly. From the central fasciculus, branches are everywhere given off, which farther subdivide, and form smaller ramifications, that terminate, at length, in a minutely reticulated structure. Around the margin of the leaf, the vessels are continued, and, at certain parts, are prolonged into the thorns that bound the circumference of this leaf. Of Leaves.

360. In this, and similar instances, the vessels appear to be ramified out of greater into less: but, as already observed (sect. 9.), this does not appear to be really the fact, the vessels being all of the same size everywhere in the leaf, and all continued through it, like so many distinct tubes. This structure Grew represents in a highly magnified view of the leaf of Borage, in table 50. of his work; part of which is represented, on a reduced scale, in fig. 13. Plate XVIII., designed to show that the ramified vessels (*o*) are all clusters of tubes of the same size, which, though they separate continually, and come into contact, are never produced, or ramified one out of another. Neither do they ever inosculate or anastomose with each other, until, according to Grew, they come to their final distribution. Vessels of the Leaf.

361. The vessels thus distributed through the leaf belong chiefly to the order of spiral vessels, as was shown by Grew in the leaf of the Vine, and many others; and, from the observations of Malpighi, Darwin, and Knight, already related (sect. 57.), it appears, that "proper vessels" are everywhere associated with them. It would seem, from the observations of Darwin, that these two orders of vessels communicate in the leaf by continuation of canal, as the arteries and veins do in animal bodies. In the stalk he considered them to be disposed in two concentric rings, the inner one of which carried out the sap to the leaves, and by the outer one it was returned to the bark. (*Phytologia*, p. 43 and 58.) In branches of the Apple and Horse-chesnut, Mr Knight also observed coloured fluids to rise through the vascular fasciculi in the petiole of the leaf. These fasciculi were surrounded by others free from colour, and which conveyed a different fluid, and, on being traced down the stalk, were found to enter the inner bark, and to have no communication with those of the wood. The *returning* vessels he describes as being situated parallel to, and surrounding those which carry up the sap. (*Phil. Trans.* 1801, p. 336.) Its proper Vessels.

362. Beside the vascular system which thus, by its ramifications, forms the skeleton of the leaf, there is another structure that requires to be noticed. We have seen that the vessels, in their ultimate distribution, form a net-work, more or less fine and minute in different leaves; so that a great number of intervascular spaces are produced. These spaces, or areæ, says Malpighi, are occupied by cellular tissue, which springs from the vessels themselves, and seems to depend from them, and by its means the thickness of the leaf is formed. In the recent part of the Borage-leaf, represented in fig. 13. Plate XVIII. this cellular structure, occupying the reticulated spaces formed by the vessels, is observed; but it is most clearly seen in thick leaves, when the cuticle has been removed, and the vessels in part dissected away. The cells or utricles which form this *parenchyme*, as it has been called, are of different figures, and are mutually contiguous; they are composed of a membrane formed into the shape of a little vesicle or bladder, from the middle of each of which, a little vascular production issues; they are all connect- Cellular Tissue of the Leaf.

Of Leaves. ed with each other, and with the vascular system of the leaf. In fig. 12. Plate XVIII. this cellular structure is represented in the leaf of *Cactus* by Malpighi, in which the oblong cells are described as proceeding from the central vessel, and mutually communicating with each other. (*Anat. Plantar.* p. 52.) A similar idea of the formation of the cells seems to have been entertained by De Saussure. In different leaves, the cells possess very different sizes and forms, and sometimes the sides of the greater ones are said to be made up of smaller. In the experiments of M. De La Baisse, they are said to have become tinged by coloured fluids conveyed from the vessels. Whether they communicate with each other is not known; but analogy, derived from other similar structures, would lead us to suppose that they communicate only with vessels, as seems to be the case in the cotyledonous leaf of the seed.

Its Follicles. 363. Beside this cellular tissue, which forms so large a portion of the leaf, certain small *follicles* are described by Malpighi as being connected with it. Between the vessels and the cells of the parenchyme, in most leaves, variously figured follicles of this kind are stated to exist, from which a peculiar *halitus* or humour is discharged; their external orifice is bounded by a rising lip, and is often furnished with hairs. They are rendered more apparent as the more succulent parts of the leaf waste; and, in different leaves, possess very different forms. (*Anat. Plantar.* p. 52.) They appear to be the *glandular* organs, described as pouring out peculiar fluids on the surface of many leaves.

364. The whole structure of vessels and cells that constitute the leaf, is covered by a cuticle variously furnished with pores, hairs, and other appendages, as already described when treating of the cuticular texture.

365. To this division of our subject belong the small leaves called *bracteæ*, *stipulæ*, &c. which serve often but a temporary purpose to the flowers and leaves; and though of some importance in the descriptive details of the botanist, are but of small consideration with the anatomist. Like the scales that envelope buds, they probably derive their origin chiefly from the cortical texture.

## Section III.

### *Of the Structure of Flowers.*

Parts of Flowers. 366. The flower is understood to comprehend the organs by which *fructification* is accomplished, and those also which surround and protect them. These organs are the *Calix*, *Corolla*, *Nectarium*, *Stamina*, and *Pistillum*. The three first are not essential parts, but the two last are indispensable. All these parts are commonly borne on a stalk called the *peduncle*, which, expanding at its extremity, forms the *receptacle*, upon which all the other parts are supported. In fig. 1. Plate XIX., is the representation of a perfect flower, in which the principal parts above mentioned are exhibited. The letter *a* denotes the corolla, formed of six petals; *b* the stamens, *c* the pistil, and *d* the peduncle of the flower. In the next figure (fig. 2.), the corolla has been removed, and the parts within it are then more clearly displayed. At the base of the flower, the calix (*e*) is seen; the pistil is composed of three parts, the ovarium (*f*), the style (*g*), and the stigma (*h*); the stamens are each distinguished into the filament (*i*), and the anther (*k*). Of Flowers.

367. The flower, as well as the leaf, originates from a bud, and, in many respects, the buds of flowers resemble those of leaves; they are covered and protected in the same manner, but they are generally larger, and have a more rounded form. They consist of two parts, the gem or eye (*oculus*), as it is sometimes called, and the *hybernaculum*, or protecting envelopes. In some trees, they spring from the extremity of particular branches; in others, from the branches in common with the leaf-buds; in others, from the axils of the leaves; and in others, from the leaf itself—but in the same *genus*, the position of the flower-buds is uniform. In fig. 3. Plate XIX. is a portion of the branch of the Peach-tree, bearing two flower-buds (*ll*), between which the smaller and more pointed leaf-bud (*m*) is placed. Flowers originate from Buds.

368. Grew discovered, and has exhibited many examples of the complete formation of the flower many months before it is destined to bloom. (*Anat. of Plants*, tab. 63, 64.) Of this fact also, Du Hamel has given several examples. In fig. 4. is a longitudinal section of the flower-bud of the Peach-tree, made in the month of February, to show the complete formation of the stamens and pistils within the surrounding envelopes of the bud. In fig. 5. is another representation of a similar bud, from which the enveloping scales have been removed; it displays the calix, which, at this period, completely envelopes the other parts of the flower. When the leaflets of the calix are separated, as is done in fig. 6. then the stamens and pistils are fully disclosed; the petals also of this flower were visible, but at this period were very small. Even the anthers were found to contain a fine dust, but no rudiment of the future embryo could be detected in the ovary. In the flower-bud of the Pear, examined in February, the parts of fructification were also visible, but indistinct; a month later, all the parts were more advanced, and the stamens, petals, and pistils were distinct; and towards the end of March, even the rudiments of future seeds were visible in the base of the pistil. (*Phys. des Arbres*, Tom. I. p. 200.) Thus it appears, that, through the winter season, the several parts of the flower are clandestinely formed, though still extremely minute. As they enlarge, their position within the bud is very various in different species; they gradually expand, and form the perfect flower, whose several parts we have next briefly to describe. Flower-buds formed in Autumn.

369. The greater number of flowers contain both stamens and pistils, and are then styled complete or perfect; but frequently it is otherwise, and such flowers are deemed incomplete or imperfect. In most instances also, there is only one set of organs of fructification on the same flower, when it is deemed simple—in others, there are more than one, and it is named compound. Our limits will permit us to describe only one of these varieties, which we shall select from the division of complete simple flowers. Kinds of Flowers.

370. The peduncle of the flower, by which all the other parts are connected with the stem or branch, is frequently single, but often divides into several Structure of the Peduncle.

Of Flowers. parts or *pedicels*, as they are named, each of which supports one or more flowers. The modes in which the flowers are disposed on the pedicels, have received different names from botanists, and to the general circumstance they assign the term *inflorescence*. The peduncle, in structure, resembles the stalk of the leaf, being formed, like it, of the several common textures. In size, in length, and other external characters, it exhibits all the varieties already noticed in the petiole of the leaf.

Structure of the Calix; 371. At the extremity of the peduncle, is placed the flower-cup or *calix*, which has very different forms, and has received, in consequence, different names. Even in its most common forms, it exhibits great variety. It is sometimes composed of a single piece, and has a tubular form; in others, of many pieces, which vary in number, position, and size, and for an account of which, we must refer to the writers on botany. In some instances, this organ falls when the fruit has set; in others, it continues till the fruit is mature; and in others, the fruit is formed within it, to which it becomes a permanent covering, and exercises the office of pericarp. The colour of the calix is commonly green, but sometimes partly red, or white, or yellow. To some flowers it is entirely wanting. From the dissections of Grew and Malpighi, it appears to be constructed, like the leaves, of a cuticle, a pretty thick cellular tissue, and of vessels, all of which exist in the peduncle, and are derived from the common textures of the plant.

of the Corolla. 372. Above the calix, the *corolla*, the chief ornament of flowers, is borne. It is enclosed by the calix, but surrounds the interior parts of the flower, and is commonly of some other colour than green. It consists of one piece, or of several; these pieces are called *petals*, and according to the number of these pieces, the corolla is variously denominated. The monopetalous corolla, or that composed of one piece, is also distinguished into several parts, expressive of form, position, or quality; and in the polypetalous variety, which consists of several pieces, each petal has its claw (*unguis*) situated at the base, and by which it is attached to the calix or receptacle, and its expanded part (*lamina*), which is of very various figure, size, and colour. At the base of the petal, a tuft of hairs is often observed, and their surface is frequently covered with a fine down, or sometimes with jointed hairs bearing globulets, as occurs on leaves. With regard to structure, Malpighi describes it as composed of the same textures as the common leaf, as is distinctly visible in the thicker varieties of it. Grew showed it to possess *spiral* vessels, a proof, as Du Hamel observes, that it is partly derived from the ligneous texture, since such vessels are not found in the bark. The odour these organs possess, leads to the belief, that they contain also a peculiar juice. (*Phys. des Arbres*, Tom. I. p. 215.)

Nectary. 373. The organ next to be noticed, is that called the *nectary* (*nectarium.*) It was observed and described by Malpighi, as a small organ situate at the base of some flowers, to which, from its figure, he gave the name of *concha*. Linnæus considered it to be the organ which bears the honey, and as belonging to the flower only; but his descriptions of it are so exceedingly vague and inconsistent, that no attempt to define and exhibit its anatomical character can be made with any hope of success.

Of Flowers. Of the Stamens. 374. Having thus described the several parts that envelope the *sexual organs*, we must now briefly notice them; and first, the *stamens*.—These, in different flowers, vary greatly in origin, size, number, figure, and mode of attachment; and upon these differences, chiefly, the Linnæan *classes* are founded. In general, each stamen is said to consist of two parts—the filament and the anther. The filaments exhibit various shapes, and are of very different size in different flowers; they are inserted occasionally into the corolla, the calix, or even the pistil; but more commonly, like the calix and corolla, are attached to the receptacle. Malpighi describes the filaments as originating from the ligneous texture, being formed of vessels and elongated cells. As they originate sometimes from petals, they must necessarily, he adds, be composed of the same parts (*Anat. Plantar.* p. 64.); and it is well known that, by culture alone, they are often reduced entirely to the condition of petals.

375. The anther is a little case or sac, formed by a thin but vascular membrane, and borne on the summit of the filament. It is filled with innumerable small particles, of various colour, size, and figure, in different plants, to which the name of *pollen* has been given. In fig. 9. A. is exhibited one of the filaments, bearing its anther, as it appears when detached from the pistil of the flower of Mallow, fig. 8. in which the particles of pollen are seen; and in fig. 9. B. these particles are represented as viewed by a still higher magnifying power. The anther itself is of very various size, figure, and colour, in different flowers; and its mode of attachment to the filament is not less subject to variation. The Anther.

376. The pollen, contained in the anthers, is described by Grew as consisting of numerous regularly figured small particles, which, in different flowers, possess a very different figure, colour, and size. Many of their forms are delineated by Grew in table 58. of his work; and in fig. 10. Plate XVIII. several representations of these forms have been copied from Du Hamel. (*Phys. des Arbres*, Tom. I. lib. 3. Plate III.) The number of particles in each anther is very great, extending, it is said, from a few hundreds to several thousands. In some flowers, the pollen consists of transparent globules; in others, they are white, purple, blue, or brown, or more frequently yellow; their surface is either smooth or rough; they are regularly organized, and when examined under the microscope, may be seen to burst, and yield a fluid, in which, according to Du Hamel, small particles are seen to float. This fluid is represented as being sometimes thin, or viscid, or oily, and is said, by Hedwig, to be discharged at once on the bursting of the little capsule that contains it; while, according to Köelreuter, it is slowly transmitted through pores in the side, or hairs on the surface of the capsule. (*Willdenow's Prin. of Botany*, p. 310.) The Pollen.

377. The parts of the flower, hitherto described, are constructed, says Malpighi, with reference to the female organ, in which the seed, the last result sought by nature, is curiously formed, and carefully guarded. This organ, called *pistillum*, consists of The Pistil.

Of Flowers. three parts, as represented in the pistil of the Almond-flower, fig. 11., in which the letter $p$ denotes the stigma, $q$ the style, and $r$ the ovary. To this latter organ Malpighi gave the name of *uterus ;* Linnæus of *germen ;* but we prefer the appellation of *ovarium*, assigned it by Gærtner. Like the stamen, the pistil exhibits great variety in form, size, number, and mode of attachment; upon which, and other peculiarities, many of the *orders*, in the Linnæan system of classification, are founded.

Its Ovary. 278. The ovarium, situate at the base of the pistil, differs greatly in size, shape, and structure, in different plants. It is the part in which the seed is formed, and, antecedent to fœcundation, vesicles, which are the rudiments of future seeds, may frequently be detected in it. Its cavity consists often of but one cell or *loculament*, in which one or more seeds are produced; sometimes it is formed into many loculaments, with which only one style communicates; and sometimes the several loculaments have communication with distinct styles. Its structure will be noticed in treating of the changes of form it undergoes in consequence of fœcundation.

Style. 379. The style, which is seated on the ovarium, and is commonly so situate in the flower, as to be surrounded by the stamens, exhibits, like all the other parts, the greatest diversity in all its external characters. It is commonly a hollow tube, which communicates, as observed above, with the ovary. Most commonly there is but one style to one ovary, but frequently more than one. In some instances, the pistils correspond in number with the loculaments, into which the ovary is divided; in other instances, every seed that is formed has its distinct pistil connected with it; while, in other examples, only one pistil is allotted to a great number of seeds. In some flowers, there is no proper style, but the stigma is placed directly on the ovary.

Stigma. 380. The stigma, which forms the summit of the pistil, presents also the greatest diversities of appearance. It sometimes terminates the style by an open mouth; sometimes it appears like a small bud; in other instances, it is variously divided or forked; sometimes it is smooth, and is sometimes covered with hairs. The number of parts into which it is divided, corresponds, in many flowers, with the number of loculaments in the ovary, as in the *Liliaceæ*, the *Umbelliferæ*, and others. (*Phys. des Arbres*, Tom. I. p. 225.) At the period of fructification, the stigma is rendered moist by a peculiar secreted fluid. Its structure resembles that of the other parts of the flower, being composed of all the common textures, and a peculiar secreting structure. Some have professed to have discovered hollow channels in the stigma, which are described as being continued through the style to the umbilical cord of the seed; but this must be regarded as doubtful.

381. The foregoing descriptions apply, in detail, only to the more perfect flower, and that variety of it which is denominated simple. For an account of the numerous diversities of form, size, position, number, and attachment, exhibited in the sexual organs of the flowers of different classes and *genera* of plants, we must refer to the writers on botany; and to the works of Malpighi and Grew for the anatomy of many of them. We have room only farther to remark, that all the several parts of the flower seem very nearly to approximate in *internal* structure; for, under particular modes of cultivation, almost any individual organ may be made to lose its original character, and to assume that of any other. Of Fruits.

## Section IV.

### *Of the Structure of Fruits, and Formation of Seeds.*

382. In the preceding section we described the structure of the flower, antecedent to fructification; we have now to exhibit, as concisely as possible, the changes of form it undergoes after that event, and particularly as it regards the production of the seed.

383. After fœcundation has been effected, the calix, corolla, stamens, and even style of the pistil, commonly fade and fall; the ovary alone remains, and undergoes very different changes of form in different plants. In the latter periods of its enlargement, it is usually called *pericarp* (*pericarpium*), a term which is understood by botanists to apply also in certain cases to the calix, the corolla, or any other apparatus of organs that serves as a support and defence to the seed. For an account of these varieties in the pericarp, and of the terms employed to express them, we must refer to the writers on botany, and more especially to the carpological labours of Gærtner, who, in his learned and elaborate work, already so often referred to, has delineated the forms, and, to a certain extent, described the structure of the pericarps and seeds in more than 1000 genera of plants. Changes from Fœcundation.

384. In its early state, the ovarium is described by Gærtner as possessing at first a simple cellular structure, which, at a later period, assumes the form of distinct cells or loculaments. Within these loculaments, minute globules or papillulæ are afterwards seen, which are the rudiments of future seeds. At this period, they are mere pulpy globules attached to their containing cells, but, in some instances, approach to the character of small vesicles. So far the rudiments of the *ovulum*, like the entire bud, are produced without fœcundation; but if that function be not performed, they scarcely acquire any increase, and at length spontaneously degenerate. The progressive series of changes that occur in the ovary itself, and in its contained ovulum, subsequent to fœcundation, have been exhibited in the almond by Malpighi, whose observations we shall briefly detail.

385. In fig. 11. Plate XIX. is represented the pistil of the Almond, as it appears soon after fœcundation, in which the ovary ($r$) is seen to be somewhat enlarged, and has an oval form. In the next figure (fig. 12.), a longitudinal section of the same pistil is exhibited, exposing the cavity of the ovary ($s$), within which a small vesicle ($t$) is placed. As the ovary (fig. 13.) enlarges, it becomes rounder, its style is contorted, and diminished in size. If in this stage it be laid open, as in fig. 14. its vessels, which, in the peduncle ($w$), are disposed cylindrically, are observed to be dilated at the place of the calix ($x$), and to give off branches to the ovary itself, and to the shell ($y$) that now begins to be formed within it. In the centre, the ovulum ($z$) is now seen to be much increased In the Ovary.

Of Fruits. in size. All the parts continue to augment; the ovary (fig. 15.) becomes rounder, and the appearance of the style is obliterated. On exposing its cavity, as in fig. 16. the ovulum (*a*) in the centre is observed to be much increased, and the outer layer (*b*) of the shelly covering that invests it now begins to harden. Such are the changes of form and structure exhibited by the ovary: we have next to trace more minutely those of the ovulum that is produced within it.

Structure of the Ovulum. 386. The earlier appearances of this body have been exhibited in figures 12. and 14. When removed from its seat, a few days after fœcundation has been accomplished, and viewed by a moderately magnifying power, it exhibits the form and appearance represented in fig. 17. Externally it is covered by a vascular tunic (*c*), derived from the inner coat of the ovarium, a part of which coat adheres to it at *d*. If in this stage the ovulum be laid open by a vertical section, as in fig. 18. it is seen to be composed of two tunics or sacs, one within the other; the inner one is filled with a cellular tissue that contains a transparent juice. To this inner tunic, the term

Its Chorion; *chorion* may be properly applied.

387. At a period a little later, when the ovulum is examined, a tubular body (*e*, fig. 19.) is observed to extend through the chorion or tunic last mentioned. Shortly after, this tube expands at its apex, and is found to contain a small vesicle. In fig. 20. which represents a section of the entire ovulum, the outer tunic, the chorion, and this tube (*f*), expanded at its

Its Amnios; apex, are exhibited. To it, the appellation of *amnios* may be given; for it is the organ in which the *embryo*, or rather the *corculum*, as at this early period it may be called, is first seen to emerge. Through several successive days, the expanded portion of this tube enlarges, and forms a sort of sac, which is filled with cellular tissue, and the summit of which, says Malpighi, the embryo is seen to occupy. In fig. 21. this amnios is separated from the other tunics, and,

its Embryo. at its summit, the embryo (*g*) is observed. If removed from its seat, the embryo presents the appearance *h* (fig. 22.), and when expanded, as in fig. 22. (*i*), is seen to consist of a body and two little wings.

Growth of the Ovulum. 388. Having thus viewed the several parts of which the ovulum is composed in their separate state, let us next observe them in connection, and trace the series of appearances they exhibit, and the effects they produce on each other. In figure 23. is given a vertical section of the entire ovulum in a more advanced state; the outer coat (*k*) still envelopes the others; the embryo (*l*) occupies the summit of the amnios (*m*), whose lower part, still tubular, is continued through the chorion (*n*). In the next figure (fig. 24.), from which the outer coat has been removed, the embryo (*o*) and the amnios (*p*) are represented as enlarged; but the chorion (*q*) is partly exhausted of its juice, and has fallen down in a collapsed state. At this period, the embryo, when separated from the amnios, has the form (*r*) fig. 25. and in its expanded state is represented by the letter *s* of the same figure. The bulk of the embryo (*t*) fig. 26. continually augments, and encroaches on the capacity of the two tunics (*v x*,) whose forms are constantly changing; and from being successively emptied of their juices, with which the embryo becomes filled, they are gradually pressed downward. At last, the embryo (*y*) fig. 27. is so much augmented as to fill the cavity of the outer tunic, and by this time the amnios and chorion, exhausted of their fluids, exhibit the shrunk and corrugated forms in which they appear at the bottom of the figure. According to this representation, the outer tunic (*k*. fig. 23.), derived from the ovary itself, and the fine membrane that immediately invests the embryo, form the only permanent coverings of the mature ovum or seed; for during the progress of formation, the chorion and amnios, which are successively produced subsequent to fœcundation, are again obliterated by the growth of the contained embryo. Malpighi describes the process of formation in many other seeds to be nearly similar; for his descriptions of which, we must refer the reader to his work. (*Anat. Plantar*. p. 71.)

389. In the above descriptions of Malpighi, the several parts seem to be clearly exhibited, except in one important particular, namely, the situation and course of the *umbilical cord*. In almost every instance, he designates the tube, which we have represented as the first form of the amnios, as the umbilical vessel (*vasculum umbilicale*), which the subsequent appearances it exhibits shows to be erroneous. In the descriptions of Grew, this deficiency in the representations of Malpighi is supplied. He has particularly observed the formation of the seed in the Apricot, which, in many respects, resembles that of the Almond; and we shall subjoin an abridged account of his observations.

Fruit of Apricot. 390. In this fruit, the pericarp that envelopes the seed is seen, in its mature state, to be composed of the pulpy part (*a*) fig. 28., within which is the osseous envelope (*b*), and at the centre, the kernel or true seed (*c*). At an early period, both the pulp and stone are observed to consist of cellular tissue; and through the stone, the vessels, passing from the peduncle, are continued. At the base of the figure, the letter *d* denotes one fasciculus of vessels continued through the stone, and turning inward where it reaches the apex of the seed. These vessels form the umbilical cord or seed-branch of Grew, while the fasciculus (*e*) that runs on the opposite side, is continued to the flower. In fig. 29. a vertical section of the ovulum, as well as pericarp, is exhibited, as it appears at a very early period; in which *f* denotes the pulp, *g* the stone, through which the umbilical vessels pass and enter the outer tunic (*h*) of the ovulum, around which they make a ring. Within this tunic is another (*i*) filled with cellular tissue, and through its axis a small tube extends, at the apex of which the embryo (*k*) is first seen to emerge.

Its Structure. 391. In fig. 30. these several parts of the ovulum are exhibited on a larger scale; the letter *l* denotes the outer tunic that immediately lines the stone; *m* the inner one, corresponding to the *chorion* of Malpighi; and *n* the tube answering to the *amnios* of the same author. Through the outer tunic, Grew represents the umbilical vessels to pass and be continued to the middle tunic; the cavity of which is occupied by large cells that contain a pure lymph. At first this tunic is entire, but soon there appears in it the small duct (*n*). This duct is not at first

Of Fruits. wider than a hair, and is dilated at each extremity into an oval cavity that contains a pure lymph. A few days after, a soft node is seen to emerge in the upper cavity of this tube. This node (*o*) fig. 31. is described to possess a conical figure, and to be another tunic filled with very minute cells. It is at first entire, but when about the size of a Carraway-seed, it becomes a little hollowed near its apex, at which part the vessels enter and terminate in another very small node, fig. 32., which is the first appearance of the embryo of the seed. This embryo, when about one-fifth part as big as a cheese-mite, begins to be distinguished by a little fissure, which marks the division of the lobes, as in fig. 33. When the lobes have increased, and are more fully formed, the node contracts at its base, fig. 34., indicating the place of the umbilical cord, which subsequently becomes the radicle of the seed. (*Anat. of Plants*, p. 209.)

392. This description corresponds nearly with that of Malpighi as far as regards the situation and general form of the tunics, and the place in which the embryo is seen first to emerge. It also displays the course of the vessels to form the umbilical cord; but the growth of the embryo in this seed, does not seem to produce the obliteration of some of the tunics in the manner delineated by Malpighi.

Structure of the Pear.

393. An example of a different kind is observed in the Pear. Its structure has been described by Grew, and more minutely by Du Hamel. In its mature state, it consists of a pulpy matter, in the centre of which are five loculaments that contain each two seeds. These appearances are exhibited in the transverse section, fig. 35.; and in the longitudinal section, fig. 36. the seeds are farther shown to be attached by a small umbilical cord. The pulp of the fruit is made up of a very fine cellular tissue, filled with the proper substance of the fruit, and is everywhere furnished with vessels. Through this pulpy matter a number of solid particles are met with, which are more particularly accumulated at the top and about the core. They are formed of an assemblage of small particles, of a stony consistence, with which a little knot of vessels (fig. 37.) is everywhere connected. In fig. 38. is a thin transverse slice, showing the relative position of these stony particles, as indicated by the knots of vessels with which they are associated. The stony matter is not observed at an early period, but seems to be deposited from the juices in a more mature state.

394. By long maceration in water, the pulpy matter is dissolved, and the vascular system is obtained separate. In the peduncle of the fruit, fifteen principal fasciculi of vessels are contained. Ten of these are distributed to the seeds and flower, and the five others are dispersed through the pulp. This vascular structure is represented in fig. 39. after the removal of the pulpy part; the larger vessels embrace the core, and, after variously ramifying, terminate in the little vascular processes before described as connected with the stony matter of the pulp. In fig. 40. is represented one of the loculaments of the capsule, with the seed in it, receiving vessels from fasciculi continued from the peduncle; and in fig. 41. an entire seed is represented, and also a section of the same, in which the umbilical vessels that enter at the base are shown, as in other instances, to be continued, beneath the tunic, to the apex of the seed. (*Phys. des Arbres*, Tom. I. p. 242.)

Ovulum of Wheat.

395. The last variety we shall notice in the formation of the seed, is that of Wheat (*triticum*), as given by Malpighi. In fig. 42. A. is represented the pistil of the flower of this plant, consisting of the ovarium (*q*), the two styles (*r*), and the feathered parts that form the stigmata. Previous to fœcundation, the ovarium is found to contain a little vesicle, fig. 42. B. which is the rudiment of the future ovulum. After fœcundation, the styles soon fall, and the ovarium acquires a more pointed figure, as in fig. 43. If now it be opened, the little vesicle has changed its appearance, and contains within it another smaller vesicle (*u*), fig. 24. The ovarium continues to alter its shape, and assumes a more oblong form, fig. 45. and the appearance of styles is now quite obliterated. Gradually the little vesicle is formed into a small plantule, convex anteriorly, fig. 46. but more hollowed within, fig. 47. and which is situated at the base of the ovarium. The two portions thus described in figures 46. and 47. are the minute germ and cotyledon of this seed, which are represented in their appropriate place in fig. 48., in which the letter *x* denotes the germ, resting in the concavity of the cotyledon; *y* the albumen that forms the chief bulk of the seed; and *x* the ovarium which, in this seed, continues permanent, and forms its outer tunic. (*Anat. Plantar.* p. 73.)

396. We have thus, in different examples, exhibited the structure of the seed; have followed the changes of form displayed in its evolution; and, in various instances, have demonstrated the construction of the several members of which the mature plant is composed. We have then described the formation of buds on the trunk, the branch, and the root, and displayed their structure in the successive stages of their evolution, by which not only new roots and branches, but leaves and flowers, are produced; and, lastly, we have followed the changes of form and condition manifested in the flower itself, from which a new seed originates, fitted to undergo and exhibit the same series of changes.

The external agents required to the accomplishment of these various changes, the circumstances in which they act, and the modes of their operation, belong to the department of PHYSIOLOGY, and will form the subjects of future consideration. (Q.)

# INDEX.


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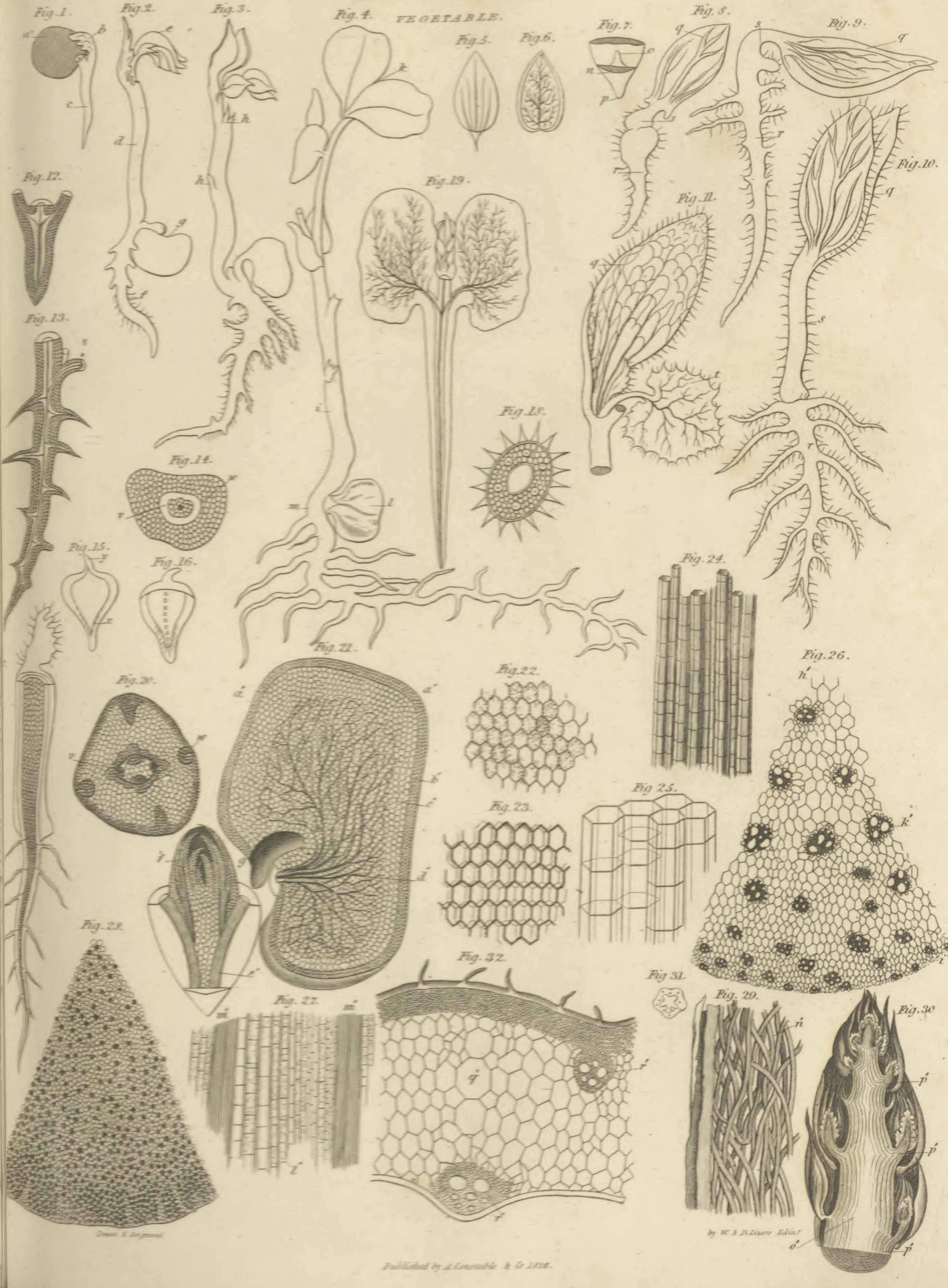
# ANATOMY. PLATE. XVI.

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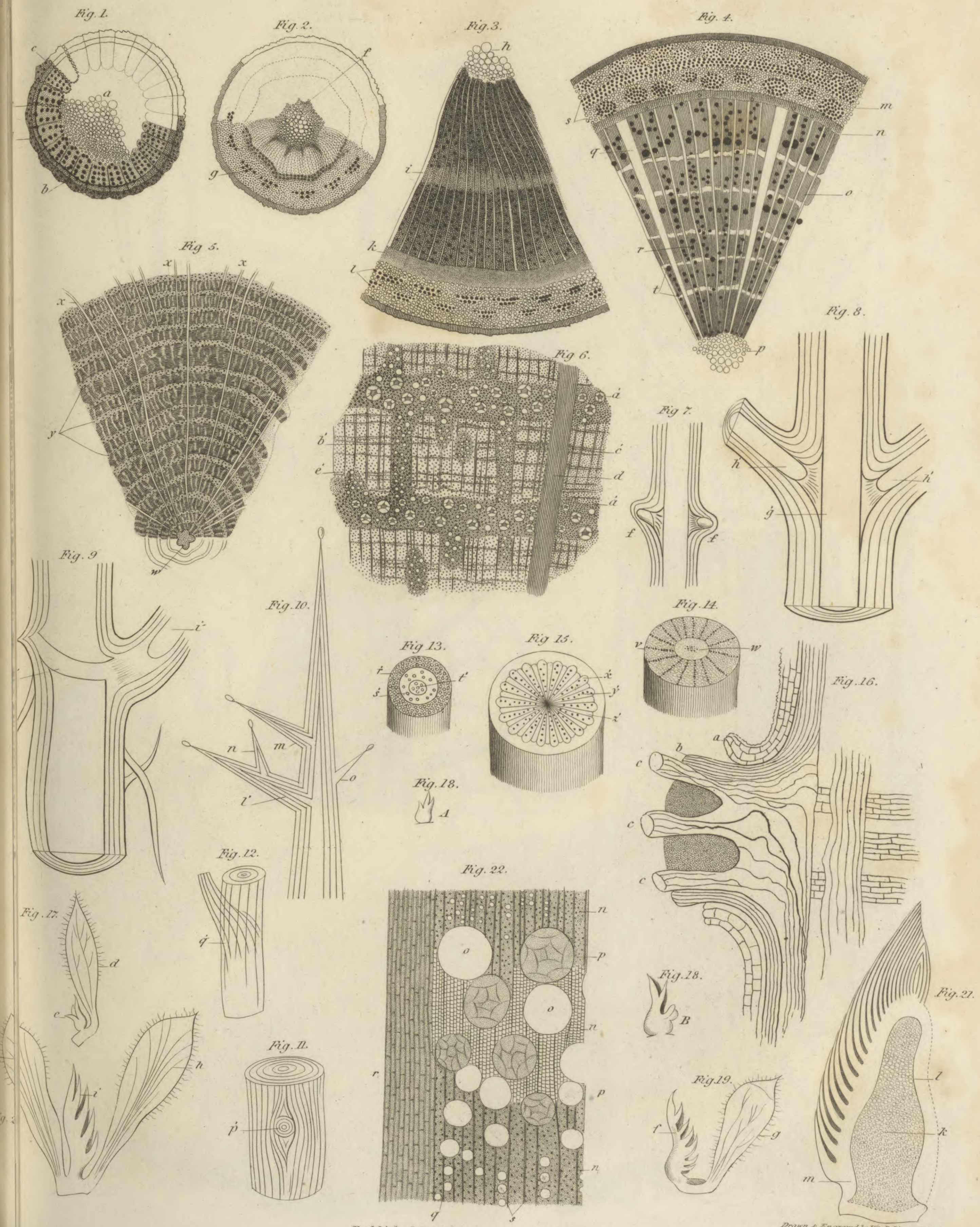
# ANATOMY.

VEGETABLE.

PLATE XVII.

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Anchor.

ANCHOR. Referring to the body of the work for a short history and description of this important Instrument, in its common form, we shall here briefly notice some recent improvements, and shall then give an account of the present method of making anchors.

Anchor with one Fluke.

The form of the common anchor is delineated in fig. 1. Plate * XX. Fig. 2. represents a new kind of anchor proposed by Mr Stuard, for which he took out a patent some years ago. It is made with one fluke instead of two; and the object of this alteration is, to prevent those accidents which sometimes happen when one ship comes in contact with the uppermost fluke of the anchor of another; and also to prevent the anchor from being tripped by the cable taking hold of it when the ship swings. In order, says Mr Stuard, in his Specification, "that this anchor may be sure to fall the right way, with the fluke downwards, I would have the shank very short; whereby, when suspended by the cable, it will cant the most, and when it has hold in the ground, the ship will ride safer; as a long shank has more power to loosen and break the ground, and is more likely to be bent or broken from its hold. Let the form of the shank, and arm of the anchor, be as AA, fig. 2. Plate * XX.; and that the parts may be stronger than if made separately, and shut together, I would have the bars which compose them in one length, so that there be no weld or joining in the whole length of the shank and arm. The hole B, is to receive the ring for the cable, and the hole C, for the stock, which is composed of a wrought-iron bolt, as A, fig. 3., covered with cast-iron at its ends, BB. The palm to be in shape as D, fig. 2., and shown detached in fig. 4., made either entirely of cast-iron, or a cast-iron shell filled with lead, which is of much more specific gravity than iron. The back of the palm to be formed either with concave surfaces, or flat surfaces, making angles at the centre. The anchor is also to have a small shackle, fixed on the bend of the shank and arm, as at E, fig. 2., for the buoy-rope to be made fast to. The shank may be made without the hole C, and the hole B, made octagonal; or if round, it should have a small fillet projecting from the stock, and a small cavity on one side of the hole B, to receive it, thus to prevent the stock from turning round; and instead of a ring for the cable, to have a shackle, fitted on the stock, on each side of the shank, and that the shackle may not turn on the stock, and fall too low, a stop is to be fixed on each side at the upper end of the shank." See *Repertory of Arts*, &c. Vol. V.

New Mooring-Anchor.

Mooring-anchors are commonly made by choosing one of the largest anchors, used for first-rate ships, weighing 80 cwt., and by bending one of the arms close down upon the shank, to prevent it catching the cable or mooring-chains whilst the ships are riding. These anchors are lowered down into the water with a very strong iron mooring-chain fastened to the ring, to which the ships are fastened; they are usually made from such as are damaged in one of the flukes or arms; but if one of this description is not to be found, a new anchor must be taken at a great expence. A new kind of mooring-anchor of cast-iron was described by Mr Hemman of Chatham, to the *Society for the Encouragement of Arts, &c. in* 1809, for which he obtained a silver medal from the Society. AA, fig. 5. Plate * XX, represents the palm or heavy part of the anchor, made very massive of cast-iron, and of considerable breadth, so that the edge B, or part which enters the ground, may have a great hold; the shank C, is made also of cast-iron, and fixed firmly to the head by passing through it, and has a small ring at *a*, where the buoy-rope is fixed; the other end of the shank goes through the stock DD, which is formed of two large wooden beams hooped together in the same manner as the stocks for common anchors; the end of the shank projects through the stock, and has a strong wrought-iron shackle E, fixed to it, by a bolt passing through both; and with this the mooring-chain is connected. The great advantage of this over the common mooring-anchors, arises from its great weight and breadth of edge to act against the ground; and being made of cast-iron, it is also more durable. A pair of these anchors, weighing 150 cwt. each, will, with the mooring-chains, cost about L. 874 less than a pair of the common anchors, which, with their chains, cost L. 2472. See Transactions of the *Society for the Encouragement of Arts, &c.* Vol. XXVIII.

Method of making Anchors.

Anchors are made from assemblages of several small bars of iron united together, by welding them into solid masses. This mode is preferable to making a single bar of sufficient size by the forge hammer in the original preparation of the iron, because the compounded bar is not liable to have any internal flaws or cracks, or at least they will not be in a transverse direction; for the bars are all examined separately before uniting them, and any which are imperfect are rejected; if, therefore, after the welding, any cracks are left between the bars, they must be in the length of the anchor, and will not deduct so materially from the strength of the whole.

The hearth AA, of the anchor-smith's forge, see fig. 6. Plate * XX, is built of brick-work, raised about 6 or 9 inches above the ground, and 6 or 7 feet square; in the centre is a large cavity, to contain the fire; at the back of the hearth a vertical brick wall B, is erected, supporting and forming one side of the chimney, which is little more than a dome placed over the hearth, and opening at top with a low chimney to carry off the smoke. Behind the wall, the bellows CD, are placed; the noses of the pipes, being about the level of the hearth, and coming through the wall; which at that part is defended from the action of the fire by a facing of fire-stone. In this fire-stone the tue-iron is fixed; it is a tube, made of wrought iron, and very thick in the substance, that it may not burn away in the fire; the pipes of the bellows are inserted in the tue-iron, and thus convey the stream of air into the centre of the fire.

The bellows are not like those which ordinary smiths make use of; but two large pair of single bellows CD, are placed horizontally by the side of each other, the pipes of both being inserted into the same tue-iron, and directed to blow to the same focus, in the centre of the fire: these bellows are exactly like those in use for domestic purposes, which only throw out air when the upper board is pressed down. The two are worked alternately by

means of chains *c d*, attached to the ends of the upper boards, and united to the end of the working levers HI, placed over each pair of bellows. From the opposite extremities of these levers, other chains *e f*, are extended to the opposite side of a long lever GG; which moves upon the pivots of a vertical axis E, and is loaded at the ends by heavy weights to give it *momentum*. Now, two or more men pushing in opposite directions, can give it a motion backwards and forwards, and by the communication of the chains and upper levers HI, they will alternately lift up the upper boards CD, of the bellows, which being sufficiently loaded, will subside themselves, and force their contents of air into the fire. The men who work the lever G, are aided by six or eight more, who place themselves upon the board of one pair of bellows, and as soon as it subsides, they step upon the other pair, which also sinks, and then they return: they have ropes suspended from the roof to enable them to lift themselves, and mount from one bellows upon the other with more ease. The common tue-iron, which is simply a cone of wrought-iron, set with clay into fire-stones, composing the back of the hearth, is very soon burnt by the great heat. The most improved forges, therefore, are now furnished with what is called the water tue-iron; which is made hollow, and water introduced into it to keep it cool. For this purpose, two cones are formed of thick iron plate, each with a small aperture at the vertex; these, when put one into the other, are welded together at their bases and their points, so as to form one cone, which is hollow, with a small space all round; two pipes communicate with the hollow, one bringing a continual supply of cold water, and the other conveying away that which is heated by the fire. By this means the tue-iron is kept cool, and can never acquire any such degree of heat as to be burned away: this tue-iron is set with fire clay into a frame of cast-iron built up in the brick-work of the wall B.

The anvil K, is only a cubic block of cast-iron placed on the ground, much lower than the ordinary smith's anvil; because, as the anchor-smiths always strike by swinging their hammers over their heads, at arms length, they have more force when the work lies low on the ground than if raised up. At a distance of eight or nine feet from the hearth AA, a strong crane gib LM, is erected, so as to turn freely upon the vertical post M; it has no tackle, but the upper beam L, which must be horizontal, has a large iron loop *n* hung upon it, with a roller *o*, which admits it to run freely backwards and forwards upon the beam; the lower end of the loop suspends the anchor; therefore, by moving the rollers along the beam of the gib, and by turning the gib round on its pivots, the anchor can be placed in any position in the fire or upon the anvil. To give motion to the roller *o*, a rack *p* is connected with it; and this is moved by a pinion upon the axis of the wheel *t*, which has an endless rope hanging down, so that a labourer can reach it, and thus remove the anchor nearer or farther from the centre, however great its weight may be. The workmen employ scarcely any other tools than their sledge-hammers, and a few large punches, cutting chissels, and sets or prints, which, when urged by the hammers, will give any particular figure to the work: the hammers are of the largest kind, and weigh from fourteen to eighteen pounds, according to the strength of the workmen. In the Royal dock-yard great use is made of a stamping machine, which the workmen call Hercules; and which is very similar to the machine for driving piles. A heavy iron weight N, guided like the ram of the pile engine, is drawn up by the strength of several men, and let fall upon the anchor, to weld the bars, in the same manner as by a forge-hammer. The machine is erected on a large block of stone, which supports the anvil O; two square iron bars PP, are fixed on each side of the anvil in a vertical position, the angles of the bars being placed towards each other. These vertical bars are eight or nine feet high, and are fixed at the top to a beam in the roof of the building, in which the machine is placed; the ram N, which weighs 4½ cwt. is fitted to slide up and down between the bars P, having notches in its sides which receive the angles of the bars; it is drawn up by a rope passing over an iron pulley Q, mounted upon pivots above the top of the vertical bars; and the rope has eight or ten small ones R, spliced into it, for as many men to act together (which they do by a similar motion to that of ringing), to elevate the ram, and let it fall upon the iron, placed upon the anvil O. The Hercules is placed in the same sweep of the crane as the anvil K, so that the iron can be conveyed to either with equal ease.

The parts of the anchor are all made separately, and afterwards united together. The first step, in making the parts, is to assemble or faggot the bars. For the centre of the mass, which is to make the shank, four large bars are first laid together; then upon the flat sides of the square so formed, smaller bars are arranged to make it up to a circle. The number is various, but in large anchors six or eight bars are laid on every side; this circle is surrounded by a number of bars arranged like the staves of a cask; as many as thirty-six are often used, and form a complete case for the others. The ends are made up by short bars to a square figure; the faggot is finished by driving iron hoops upon it at sufficient distances; see W in the figure; and it is suspended from the crane in such a manner, that it can be moved and turned in any direction, by only one or two men, even when it weighs three tons. For this purpose, an iron pulley *k* is hooked to the iron loop *n* of the crane, and a short endless chain *l*, passed over the pulley, suspends the faggot in its loop: in this manner, the weight of the iron is in reality borne by the pivot of the pulley *k*, and the mass can be easily turned round upon its centre to bring any side upwards. To give a power to the man who guides it, one of the four central bars is double the length of the faggot, and projects, see *g*, to form a long lever by which it is steered; and two holes are made through the end of this bar to insert a cross lever *h*, by which the faggot is turned or rolled round upon its centre. As the faggot hangs very nearly on a balance in the loop of the chain *l*, the man, by weighing on the end of the long bar *g*, can easily raise up its end from the anvil K; and swinging the crane on its pivots, he can move it into the fire, which is made

up hollow like an oven. To effect this form, the fireman first spreads the coals evenly upon the hearth, and with his shovel or slice makes a flat surface about the level of the tue-hole; he then arranges some large cinders or cakes round in a circle upon this surface, and by other cinders builds it up like an oven or dome, leaving a mouth to introduce the iron. The oven is adapted in size to the magnitude of the mass of iron; and must be brought forwards upon the hearth, to leave a space between its interior cavity, and the orifice of the tue-iron; in which space a passage is made from the tue-hole to the fire, and filled up with large lighted coals, and then covered up by small coals. The blast from the bellows passes through these hot coals, in order that the cold air may not enter the fire at once, and blow on the iron, but be first converted into flame; which is urged forcibly into the oven, and is reverberated from the roof and sides upon the iron placed in the centre. As the floor of the oven is nearly upon a level with the tue-hole, the flame from the coals between it and the fire also plays upon the bottom, and thus heats the iron on all sides. The outside of the dome is covered over with a considerable thickness of small coals, which cake together, and, as the inside of the oven consumes, settle down into a dome again, which the smith aids by striking the outside with the flat of his slice. If the fire breaks out at any place in the roof, the smith immediately repairs the breach with fresh coals, and damps them with water, that they may not burn too fast; for if the inside of the oven burns very fierce, the flames will not be reverberated so forcibly as when it is in the state of burning cake. Care must likewise be taken to prevent the fire burning back to the tue-iron. The mouth of the oven should be made no larger than to admit the work, and that as little heat as possible may escape by the iron, the mouth is filled round it with coals. F is an iron screen hung on hinges, to swing before the mouth of the fire when the iron is withdrawn, that the workmen may not be scorched by the heat.

All the men unite to assist in blowing the bellows, which they work in the manner already described, from half an hour to an hour, according to the size of the anchor, until they have raised the iron to a good welding heat. The mouth of the fire is opened occasionally to inspect the process, and the faggot is turned in the fire, if it is not found to be heating equally in every part. Eight men, and sometimes more, are employed to forge an anchor; six of them strike with the hammers, one is stationed at the guide bar, and the eighth, who is master or foreman, directs the others, and occasionally assists to guide the anchor. When the whole of that part which is in the fire comes to a good welding heat, the workmen leave the bellows and take up their hammers; the coals are removed from the iron, which is swung out of the fire by the man who guides it, assisted by others, and the hot end placed on the anvil; during which time, one or two labourers with birch brooms sweep off the coals which adhere to it.

The smiths now begin hammering, one-half the number standing on one side and the other half on the other; they use large sledges, weighing from sixteen to eighteen pounds, and faced with steel, striking in regular order, one after the other, swinging the hammers at arms length, and all striking nearly at the same place: the foreman places himself near the man who guides, and with a long wand points out the part he wishes them to strike, and at the same time directs, and sometimes assists the guide to turn the faggot round, so as to bring that side uppermost which requires to be hammered. This is continued as long as the metal retains sufficient heat for welding. This process is exceedingly laborious for the workmen, and is much more effectually performed by means of the Hercules, which strikes such powerful blows upon the iron as to consolidate the bars much more than the strokes of small hammers can do, however long they may be continued. When the iron has lost so much of the heat, that it will no longer weld, the foreman takes a number of pins, made like very thick nails without heads; one of these he holds in the end of a cleft stick, places its point upon the iron, and two smiths, with their sledges, strike on it with all their force, to drive it through the bars; but this they must do quickly, or the pins will become hot and soft, so as not to penetrate the bar. These pins are intended to hold the whole together more firmly, and by swelling out the sides, to fill up any small spaces there may be between the bars. The iron is now returned to the fire; another mouth being opened on the opposite side of the oven, to admit the end or part which has been welded to come through, that a part further up the faggot may be heated; and when this is done, the welding is performed in the same manner as before. Thus, by repeated heatings, the faggot is made into one solid bar of the size and length intended; it is then hammered over again at welding heats to finish it, and make an even surface; and in this second operation, the workmen do not leave off hammering as soon as the iron loses its full welding heat, but continue till it turns almost black. This renders the surface solid and hard; and closes all small pores at which the sea-water might enter, and by corroding the bars, expand them, and, in time, split open the mass of iron.

The shank for an anchor is made larger at the lower end, where the arms are to be welded to it, and is of a square figure; a sort of rebate or scarf (*s*) is here formed on each side the square, in order that the arms may apply more properly for welding. This scarf is made in the original shape of the faggot, and finished by cutting away some of the metal with chisels whilst it is hot, and using sets or punches, properly formed to make a square angle to the shoulder of the scarf. The upper end of the shank is likewise square, and the length between these square parts is worked either to an octagon or round, tapering regularly from the lower to the upper end. The hole to receive the ring of the anchor is pierced through the square part at the upper end, first by a small punch, and then larger ones are used till it is sufficiently enlarged: the punch is made of steel, and, when it is observed to change colour by the heat, it is struck on the opposite end to drive it out, and is instantly dipped in water to cool it, and another driven in. The projecting pieces or nuts, which are

Anchor.

to keep the stock or wooden beam of the anchor, and its place on the shank are next welded on. To do this, the shank is heated, and, at the same time, a thick bar is heated in another forge; the end of this is laid across the shank; and the men hammer it down to weld it to the shank, then the piece is cut off by the chisel, and another piece welded on the opposite side.

Whilst this process of forging the shank is going on, the smiths of another forge, placed as near as convenient to the former, are employed in making the arms, which are made from faggots in the same manner as the shank, but of less size and shorter; they are made taper (see X), one end of each being smaller than the other; the larger ends are made square, and cut down with scarfs (*r*) to correspond with those (*s*) at the lower end of the shank. The middle parts of the arms are rounded, and the outer extremities are cut away as much as the thickness of the flukes or palms *m*, that the palms may be flush with the upper sides when they are welded on. The flukes are generally made at the iron forges in the country, by the forge hammer; but in some yards are made by faggoting small bars, leaving one long one for a handle; when finished they are welded to the arms, which have then the appearance of X.—The next business is to unite the arms to the end of the shank; and, in doing this, particular care is necessary; as the goodness of the anchor is entirely dependent upon its being effectually performed. In so large a weld, the outside is very liable to be welded, and make a good appearance while the middle part is not united; to guard against this, both surfaces of the scarfs should be rather convex, that they may be certain to touch in the middle first. When the other arm is welded, the anchor is complete except the ring, which is made from several small bars welded together, and drawn out into a round rod, then bent to a circle, put through the hole in the shank, and its ends welded together. If the shank or other part is crooked, it is set straight by heating it in the crooked part, and striking it over the anvil, or by the Hercules. After all this, the whole is heated, but not to a white heat, and the anchor hammered in every part, to finish and make its surface even: this is done by lighter hammers worked by both hands, but not swung over the head. This operation renders the surface of the metal hard and smooth; and if very effectually performed, the anchor will not rust materially by the action of the sea water. The hammering is continued till the iron is quite black and almost cold. It is common with some manufacturers, after they have made up the shank, to heat it again, and apply the end of a thin flat bar properly heated upon it; then by turning the large shank round, the bar is wound spirally upon it, so as to form a complete covering to the whole. This method admits of employing a kind of iron, which is less liable to corrosion, but we fear it is sometimes resorted to, to conceal the bad qualities of the iron of which the anchor is composed.

The iron from which anchors are made ought to be of the best quality; that kind of it which is called red short, will not bear sufficient hammering to weld the bars, and cold short, from its brittleness, is not to be depended upon when the anchor is in use. A good anchor should be formed of the toughest iron that can be procured. (R.)

Anderson.

We shall have some farther particulars to mention in regard to anchors, when we come to the article Dock-yards.

ANDERSON (Alexander), a very eminent Mathematician, who flourished in the early part of the seventeenth century. He was born at Aberdeen, but passed over to the Continent, and settled as a private teacher or Professor of Mathematics at Paris, where he published or edited, between the years 1612 and 1619, various Geometrical and Algebraical tracts, which are conspicuous for their ingenuity and elegance. It is doubtful whether he was ever acquainted with the famous Vieta, Master of Requests at Paris, who died in 1603; but his pure taste and skill in mathematical investigation, had pointed him out to the executors of that illustrious man, who had found leisure, in the intervals of a laborious profession, to cultivate and extend the ancient geometry, and by adopting a system of general symbols, to lay the foundation, and begin the superstructure of Algebraical science, as the person most proper for revising and publishing his valuable manuscripts. Anderson did not come forward, however, as a mere editor; he enriched the texts with learned comments, and gave neat demonstrations of those propositions which had been left imperfect. He afterwards produced a specimen of the application of Geometrical Analysis, which is distinguished by its clearness and classic elegance.

Of this able geometer, we are ignorant both of the time of his birth and of his death. His brother, David Anderson, a small proprietor in Aberdeenshire, but engaged in business, had likewise a strong turn for mathematics and mechanics, which, joined to great versatility of talent, made him be regarded by his neighbours at that period as a sort of oracle. The daughter of this clever and active burgess, was married to John Gregory, minister of Drumoak, in that county, father to the celebrated James Gregory, inventor of the reflecting telescope, and is supposed to have communicated to her children that taste for mathematical learning which afterwards shone forth so remarkably in the family of the Gregorys.

The works of Anderson amount to six thin quarto volumes, which are now very scarce. These are:

1. Supplementum Apollonii Redivivi; sive analysis problematis hactenus desiderati ad Apollonii Pergæi doctrinarum περι νευσεων, a Marino Ghetaldo Patritio Ragusino hujusque non ita pridem institutam. In quâ exhibetur mechanice æqualitatem tertii gradus sive solidarum, in quibus magnitudo omnino data æquatur homogeneæ sub altero tantum coefficiente ignoto. Huic subnexa est variorum problematum practice. Paris, 1612, in 4to.—This tract refers to the problem of *inclinations*, by which, in certain cases, the application of the curve called the *conchoid* is superseded.
2. Αιτιολογια: Pro Zetetico Apolloniani, problematis a se jam pridem edito in supplemento Apollonii Redivivi. Ad clarissimum et ornatissimum virum Marinum Ghetaldum Patritium Ragusinum. In qua ad ea quæ obiter mihi per strinxit Ghetaldus

# ANCHOR.

PLATE*XX.

Fig. 1.

COMMON ANCHOR.

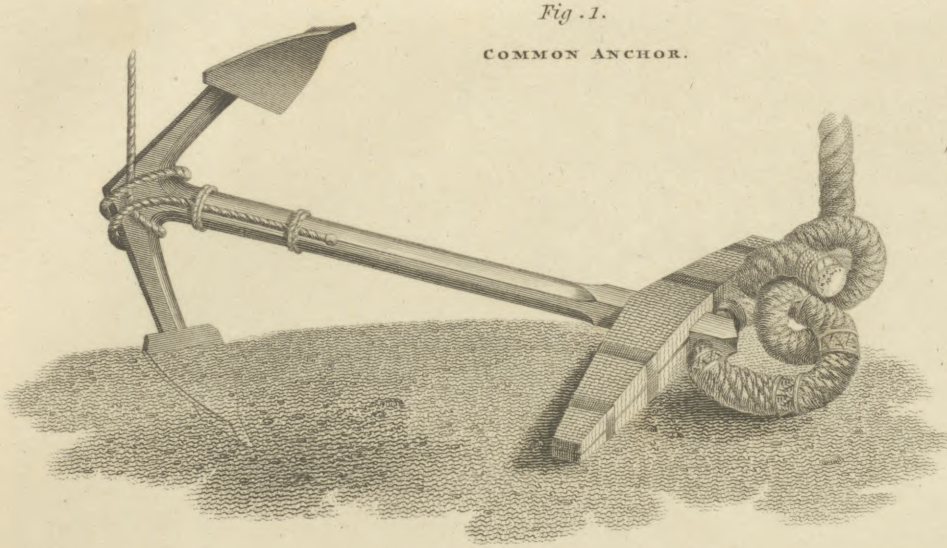


Fig. 2.

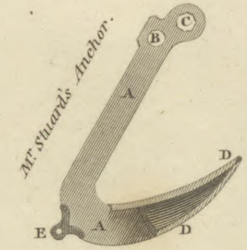



Fig. 3.

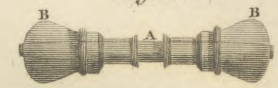



Fig. 4.

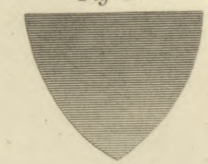
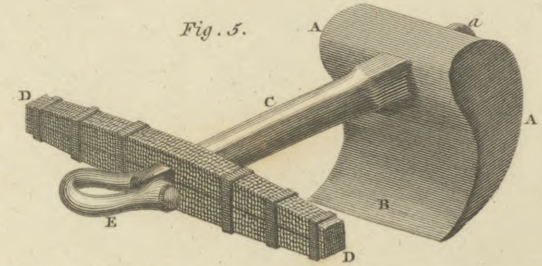


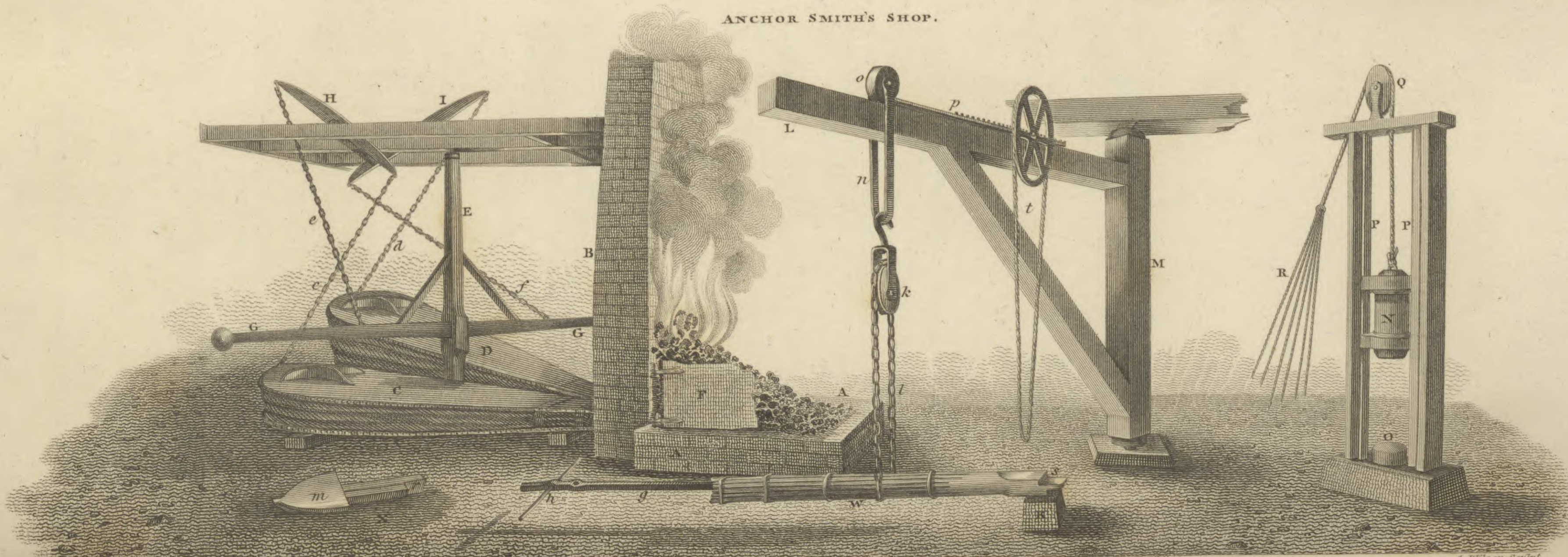
Fig. 5.




NEW MOORING ANCHOR.

Fig. 6.

ANCHOR SMITH'S SHOP.




J. Farey Junr. Delt.

A. Wilson Sculpt.

Published by A. Constable & Co. 1816.

respondetur, et analytices clarius detegitur. Paris, 1615, in 4to; being an addition to the former.

3. Francisci Vietæ Fontenacensis de Aequationum Recognitione et Emendatione Tractatus Duo. Paris, 1615, in 4to; to which Anderson has supplied the dedication, preface, and appendix.
4. Ad Angularium Sectionum Analyticen Theoremata Καθολικώτερα. A Francisco Vieta Fontenacensi excogitata, at absque ulla demonstratione ad nos transmissa, jam pridem demonstrationibus confirmata. Paris, 1615, in 4to.
5. Vindiciæ Archimedis. Sive, Elenchus Cyclometriæ novæ à Philippo Lansbergio nuper editæ. Paris, 1616, in 4to.
6. Alexandri Andersoni Scoti Exercitationum Mathematicarum Dicas Prima. Continens, Quæstionum aliquot, quæ nobilissimorum tum hujus tum veteris ævi, Mathematicorum ingenia exercuere Enodationem. Paris, 1619, in 4to. (D.)

ANDERSON (Dr James). The subject of this article, who has been brought into notice, principally from the more recent encouragement given to agriculture, and the versatility of his own genius, was born at the village of Hermandston, in the county of Edinburgh, in the year 1730. His parents were in humble life, and had possessed a farm for some generations, which he was destined to inherit and to cultivate. At that period improvement was in infancy, and the husbandman had to contend with a climate, whose uncertainty seemed to keep pace with the progress of his skill, and which too often disappointed him of the fruits of his industry. Anderson, while yet at an early age, lost his parents; however, his education was uninterrupted, and conceiving that an acquaintance with Chemistry would promote his profession, he attended a course of lectures on that science, then delivered by Dr Cullen. None of the other pupils besides himself took notes of his lectures, which being afterwards surreptitiously obtained from him, with the design of publication, he defeated the intended purpose, apprehensive that his preceptor's fame might be diminished by these imperfect transcripts. His own active occupations had already commenced, and along with the practice of husbandry, he prosecuted his original taste for literature.

Enlarging the sphere of his employments, Anderson forsook his first possession, for a farm of 1300 acres, which he rented in Aberdeenshire, though nearly in a state of nature, and where agriculture is still behind the southern districts. But, previous to this, he became known to men of letters, by some Essays on planting, which, under the signature Agricola, he ventured to commit to the world through the medium of the Edinburgh Weekly Magazine, in 1771. Soon embarking in a higher sphere of literature, he composed the article *Monsoon*, for the first edition of this *Encyclopædia*, in 1773, wherein he threw out some luminous ideas, and among other observations, predicted, from physical facts, and the state of geographical knowledge, that no polar continent would be found by the circumnavigators then employed by Government. In the year 1777, he published a considerable quarto volume, said to have been composed two years preceding, on the means of exerting a spirit of national industry, with regard to Agriculture, Commerce, Manufactures, and Fisheries; and in this, he enters into detailed views of many subjects of Political Economy. The interest of the Highlands and Islands of Scotland is in a particular manner considered, and the author maintains, that the only effectual means of increasing agriculture, is by promoting manufactures; as also, that the neglect which the agriculture of these parts of the kingdom experienced, resulted from the neglect of manufactures. Scotland, he affirms, is better adapted than England for the production of wool, and this, as well as other products, he thought, would be best encouraged by premiums. The advantages which might result from attending to the fisheries, he judged would be very great, and the shoals of herring frequenting the coast, could be converted to a source of national wealth under suitable establishments. Dr Anderson, who, soon after, had the degree of Doctor of Laws conferred on him by the University of Aberdeen, did not abandon these inquiries. He printed a tract regarding the fisheries, which was circulated among his friends; and, in consequence of being more widely diffused, he was appointed, by the Lords of the Treasury, to survey the western coast of Scotland, for the purpose of obtaining satisfactory information on the subject. This he did in 1784, and received the full approbation of his employers; and he published a brief account of the Hebrides, a chain of Islands then as little within the general acquaintance of the inhabitants of Great Britain, as if they had been under the dominion of another country. The principal obstacles to the fishery, Dr Anderson considered, were to be found in a duty on salt and coals, and he recommended the repeal of both. It is certain, that, from thenceforward, this great branch of national industry has received infinitely more patronage than before his report, and, while we only shared the labours of the Dutch for centuries, the fisheries on our own coast have since been monopolized by ourselves. Nothing can be more impolitic than to fetter the exertions of the industrious by exorbitant duties; or equally oppressive, with denying fuel to the poorer classes where it is scarce, by duties on its importation.

Dr Anderson had now withdrawn from his northern farm, where he resided above twenty years, and settled in the vicinity of Edinburgh. His agricultural speculations were still continued, and, when a Parliamentary grant was about to be proposed to Mr Elkington, for a particular mode of draining land, he reclaimed the practice as having been observed by himself many years anterior. Repeated examples, indeed, prove that the rewards granted by Parliament for improvement are attended with such slight investigations, that the merits of real invention are overlooked. Dr Anderson now projected a periodical publication, called the *Bee*, consisting of miscellaneous original matter, which attained the extent of eighteen volumes in octavo. It was published weekly, and a large proportion of it came from his own pen, which is seldom a prudent course in an Editor. The relation of Great Britain and her Colonies, and the political rights of man-

kind, — subjects which had excited strong interests throughout Europe,—also received some commentaries from Dr Anderson. He wrote a tract, called *The Interest of Great Britain with respect to her Colonies*, and commenced a correspondence with General Washington, which was afterwards published.

Towards the year 1797, he again removed to Islesworth, in the neighbourhood of London, where he undertook another periodical publication, appearing at more distant intervals than the former, entitled *Recreations in Agriculture, Natural History, Arts, and Miscellaneous Literature.* This work was prefaced by two copious dissertations, the one on Agriculture, the other on Natural History; and opened with a discussion regarding a very curious and important subject, namely, an inquiry into what are denominated varieties in plants and animals. Many useful and interesting remarks appear in the course of this publication, a portion of which was supplied by other contributors, and it is embellished by beautiful vignettes from engravings on wood. Owing to some difficulties attending the publication, it ceased in 1802, having subsisted three years. Though natural history is rather predominant, the rest of his leading subjects are not overlooked. Dr Anderson henceforward lived in a great measure in retirement, though occasionally reminding the world of his wonted inquiries, by the publication of tracts on unconnected subjects. He obtained a patent for an improved Hot-house, wherein no fuel was used; and employed himself in experiments regarding the degree of temperature and humidity most beneficial to plants. Likewise, having observed the uncommon depredations of wasps, he is said, after satisfying himself of their manner of increase, to have devised a plan for their absolute extermination. This was chiefly by the destruction of the females before founding their respective colonies by the depositation of innumerable eggs; and hand-bills were circulated under the auspices of an association formed by him, offering a reward for every female brought in dead within a specified time. It does not appear, however, that the breed was at all diminished by the proposed expedient.

Dr Anderson still remained in his retreat, enjoying the cultivation of his garden, and nothing of importance is known to have proceeded from his pen. After a gradual decline, partly occasioned by the over-exertion of the mental energies, he died in the year 1808, aged 69. He was twice married; first to Miss Seton of Mounie; secondly, to an English lady. By his first marriage he had thirteen children, six of whom survived him. One of his sons, who died a few years ago, made distinguished progress in the art of engraving on wood; and, if the vignettes of the *Recreations in Agriculture* are executed by him, they afford ample testimony of his abilities.

Dr Anderson was endowed with a vigorous understanding, which he chiefly displayed in treating of agricultural matters, and those connected with rural economy; but he was, at the same time, of a versatile talent, which could readily be occupied on transient facts and occurrences. Many of his works were of a fugitive nature, consisting of small impressions, which were not renewed, and hence are difficult to be obtained at present, if they have not totally disappeared. None of them soar to the more lofty regions of science; they are directed to practical views in useful projects, and, for the most part, relate to subjects of ordinary detail. Of this the reader will be enabled to judge by the subjoined list, which we believe is the most copious that has yet appeared. The industry of Dr Anderson was indefatigable, whether in personal exertion, or mental energy, and he possessed elevated sentiments of independence. During a period of overstrained political fervour, certain papers formed part of the periodical works already referred to, which were thought libellous on the Government. Although Dr Anderson's principles were noted for attachment to the existing administration, he was called upon to give up the author of the obnoxious compositions, which he steadily refused, and, even in the face of the civil magistrates, charged his printers not to violate their fidelity to him and the author in betraying his name. The business terminated here, until a factious individual insinuated to the same magistrates, that the compositions had proceeded from one of the Supreme Judges, whose party politics were avowedly hostile to those of Government. Dr Anderson having learned the reproach, hastened to relieve the object of it by divulging the name of the real author, who, to the universal surprise of the public, proved to be none other than the traducer himself.

1776. A Practical Treatise on Chimneys, containing full instructions for constructing them in all cases, so as to draw well, and for removing smoke, 12mo.

1776. Free Thoughts on the American Contest, 8vo.

1777. Observations on the Means of exciting a Spirit of National Industry, 4to.

1777. Miscellaneous Observations on Planting and Training Timber Trees, by Agricola, in 8vo.

1777. An Inquiry into the Nature of the Corn Laws, in 8vo.

1777. Essays Relating to Agriculture and Rural Affairs, 8vo. A fifth edition, in 3 volumes, was published in 1800.

1779. An Inquiry into the Causes that have hitherto retarded the Advancement of Agriculture in Europe, 4to.

1782. The Interest of Great Britain, with regard to her American Colonies, considered, 8vo.

1783. The True Interest of Great Britain considered, or a Proposal for Establishing the Northern British Fisheries, 12mo.

1785. An Account of the Present State of the Hebrides and Western Coasts of Scotland, being the Substance of a Report to the Lords of the Treasury, 8vo.

1789. Observations on Slavery, particularly with a View to its Effects on the British Colonies in the West Indies, 4to.

1790. Papers by Dr Anderson and Sir John Sinclair on Shetland Wool, 8vo.

1791. The Bee, 18 vols. 8vo.

1792. Observations on the Effects of the Coal Duty, 8vo.
1793. Thoughts on the Privileges and Powers of Juries, with Observations on the State of the Country with Regard to Credit, 8vo.
1793. Remarks on the Poor's Laws of Scotland, 4to.
1794. A Practical Treatise on Peat Moss, 8vo.
1794. A General View of the Agriculture and Rural Economy of the County of Aberdeen, and the Means of its Improvement, 8vo.
1794. An Account of the Different Kinds of Sheep found in the Russian Dominions, by Dr Pallas. With five Appendixes, by Dr Anderson, 8vo.
1795. Two Letters, to Dr Edward Home, on an Universal Character, in 8vo.
1797. A Practical Treatise on Draining Bogs and Swampy Grounds, with Cursory Remarks on the Originality of Elkington's Mode of Draining Lands, 8vo.
1799. Recreations in Agriculture, 6 volumes 8vo.
1800. Selections from Correspondence with General Washington, 8vo.
1801. A Calm Investigation of the Circumstances that have led to the Present Scarcity of Grain in Great Britain; suggesting the means of alleviating that evil, and of preventing the occurrence of such a calamity in future, 8vo.
1803. Description of a Patent Hot-house, which operates chiefly by the Heat of the Sun, and other Subjects, 8vo.

Dr Anderson besides wrote many papers in periodical publications, and an account of Ancient Fortifications in the Highlands, read to the Society of Scotish Antiquaries. (s.)

ANDES. The *Encyclopædia* contains such particulars relative to that amazing chain of mountains as could be gathered from the accounts of the early writers, and especially from the more precise descriptions given by the Academicians who were sent to Peru in 1736, to measure the length of a degree of the meridian under the Equator. But, since that period, Geography has made rapid advances, and Mineralogy, emerging from its obscurity, has risen to the rank of a science. The vast American Continent has been explored in different directions, by adventurous and intelligent travellers. Of these by far the most conspicuous for enterprise, accuracy of observation, and extent of scientific research, is the celebrated Humboldt, whose various discoveries in the regions of the New World have deservedly excited so much interest. The narrative, however, of this accomplished traveller is not yet completed, and we must content ourselves at present with combining the incidental sketches which occur in his other publications. We trust that we shall be enabled to give a fuller and more precise account of the Andes in the article MOUNTAINS.

The Andes are distinguished above all the known mountain-chains, by their immense extent and their prodigious altitude. They run almost parallel to the west coast of the southern Continent of America, at a mean distance of between 100 and 200 miles, rising in some places to the enormous height of 20,000 feet; and stretch from the mouth of the river Atrato, on the isthmus of Darien, in the latitude of 8 degrees north, as far as Cape Pilares, at the outlet of the Straits of Magellan, in the 53d degree of south latitude,—a range of at least 4200 miles. According to Humboldt, they send out, nearly at right angles to their colossal ridge, three dependent branches, called likewise *Cordilleras* by the Spaniards.

Of these secondary chains, the *first* and most northern is that of the coast of Venezuela, which is besides the highest and narrowest. With an irregular altitude, it bends eastwards from the Atrato, forming the Sierra of Abibé, the mountains of Cauca, and the high Savannahs of Folu, till it reaches the stream of Magdalena, in the province of St Martha. It contracts, as it approaches the Gulf of Mexico at Cape Vela; and thence extends to the mountain of Paria, or rather the Galley-Point in the island of Trinidad, where it terminates. This secondary chain attains its greatest known elevation where it rears the snowy summit, or Sierra Nevada, of St Martha and of Merida, the former being nearly 14,000, and the latter above 15,000 feet, in altitude. These insulated mountains, covered so near the equator with eternal snow, yet discharging boiling sulphureous water from their sides, are higher than the Peak of Teneriffe, and can be compared only with Montblanc. In their descent, they leave the Paramo or lofty desert of Rosa and of Mucachi; and on the west side of the lake Maracaybo, they form long and very narrow vales, running from south to north, and covered with forests. At Cape Vela, the mountain-chain divides into two parallel ridges, which form three confined vallies, ranging from east to west, and having all the appearance of being the beds of ancient lakes. These ridges, of which the northern is the continuation of the Sierra Nevada of St Martha, and the southern the extension of the snowy summits of Merida, are united again by two arms which seem to have been placed by the hand of nature, as dikes to confine the primeval collections of water. The three vallies thus enclosed are remarkable for their elevation above the sea, rising like steps one above another, the eastmost, or that of the Caraccas, being the highest. This plain was found by Humboldt to be elevated 2660 feet, while the basin of Aragua has only 1350 feet in height, and the Llanos, or reedy plains of Monai, spread within 500 or 600 feet above the level of the shore. The lake of the Caraccas appears to have forced a passage for itself through the *quebrada*, or cleft of Tipé, while that of Aragua has been gradually dissipated by a slow process of evaporation, leaving some vestiges of its former existence in pools charged with muriate of lime, and in the low islets called *Aparecidas*. The medium height of the Cordillera of the coast is about 4000 or 5000 feet; but its loftiest summit, next to the Sierra Nevada of Merida, is the *Silla* (or saddle) of the Caraccas, which was visited by Humboldt, and ascertained from barometrical measurement to have an elevation of 8420 feet. Farther to the eastward, the mountain-chain becomes suddenly depressed, especially its primitive rocks; the beds of gneiss and mica slate, meeting as they advance with accumulations of secondary calcareous substances, which envelope them completely, and rise to a great eleva-

tion. The incumbent mass of sandstone, with a calcareous base, extending from Capelluari, forms a detached range of mountains, in which no trace of primitive rock is found.

The *second* branch, which stretches from the Andes across the American Continent, and exhibits a chain of primitive mountains, is named by Humboldt the *Cordillera of the cataracts of Orinocco*. This very enterprising traveller surveyed it over an extent of upwards of 600 miles, from the Black River to the frontiers of the Great Bara; but the rest of the chain is very little known, running through unexplored wilds and regions almost inaccessible, occupied by fierce and independent tribes of savages. It leaves the great trunk between the 3d and 6th degree of southern latitude, and runs eastwards from the *Paramo*, or high desert of Tuquillo and St Martin, and the sources of the Guaviari, rearing the lofty summits of Umama and Canavami, and pouring forth the large rivers Meta, Zama, and Ymerida, which form the *roudals*, or tremendous rapids of Aturé and Maypuré, the only openings existing at present between the interior of the Continent and the plain of the Amazons. Beyond these cataracts, the chain of mountains again acquires greater elevation and breadth, occupying the vast tract enclosed between the rivers Caura, Cavony, and Padamo, and stretching southwards to the boundless forests where the Portuguese settlers gather that potent drug, the *sarsaparilla*. Farther eastwards this chain is not traced, no European or civilized Indian having ever explored the sources of the Orinocco; all access in that quarter being prevented by the ferocity of the Guaicas, a dwarfish but very fair and warlike race, and by the valour of the Guajaribos, a most desperate tribe of cannibals. Beyond these recesses, however, we are made acquainted with the continuation of the chain of the cataracts, by the astonishing journey performed by Don Antonio Santos, who, disguised like a savage, his body naked, and his skin stained of a copper colour, and speaking fluently the several Indian dialects, penetrated from the mouth of the Rio Caronis to the Lake of Parimé and the Amazons. The range of mountains sinks lower, and contracts its breadth to 200 miles, where it assumes the name of Serrania de Quimeropaca and Pacaraimo. A few degrees farther eastwards, it spreads out again, and bends south to the Canno Pirara along the Mao, near whose banks appears the Cerro or hill of Ueucuamo, consisting entirely of a very shining and yellow mica slate, which has therefore procured from the credulity of early travellers the magnificent appellation of *Dorado*, or Golden Mountain. East from the river Esquibo, this Cordillera stretches to meet the granitic or gneiss mountains of Dutch and French Guyana, inhabited by confederated bands of Negroes and Caribs, but giving birth to the commercial streams of Berbice, Surinam, and Marony.

The chain of the cataracts of Orinoeco, has only a mean height of about 4000 feet above the level of the sea. The greatest elevation occurs where the mountain of Duida rears its enormous mass from the midst of a luxuriant plain, clothed with the tropical productions of Palms and Ananas, and discharges from its steep sides, about the close of the rainy season, volumes of incessant flames. No one has yet had the resolution or perseverance to climb through the tangling and rampant bushes to its peak, which, measured trigonometrically, gives an altitude of 8465 feet above the sea. The whole mountain-group which forms this Cordillera, is distinguished by the abrupt descent of its south flank; nor is it less remarkable for containing no rock of secondary formation, or exhibiting any vestige of petrifactions and organic remains. It contains only granite, gneiss, mica slate, and hornblende, without any casing or admixture of sandstone or calcareous matter.

The *third* great branch sent out from the trunk of the Andes, is that of the *Chiquitos;* which province it traverses, making a sort of semicircular sweep between the parallels of 15 and 20 degrees south latitude, and appearing to connect the colossal heights of Peru and Chili, with the mountains of Brazil and Paraguay. It supplies the rivers that feed the Marānon on the one side, and the Plata on the other The structure and disposition, however, of the Cordillera of the Chiquitos still remain almost unknown.

These grand chains of mountains divide the southern Continent of America, from the latitude of 19 to that of 52 degrees, into three immense plains, which on the west side are shut up by the enormous ridge of the Andes, but are all open on the east, and towards the Atlantic Ocean. The most northern is the valley of the Orinocco, consisting of savannahs or level tracts covered with reedy herbage and scattered Palms. The next is the plain of the Marānon, which is entirely covered with dense impenetrable forests. The third and southmost valley is the Pampas; a dead flat of most prodigious expanse, clothed, like that of the Orinocco, with a coarse rank herbage, and abandoned to the occupation of countless herds of wild cattle.

Of these immense plains, the subsoil resembles the composition of the neighbouring mountains. In the valley of the Orinocco, the primitive rock is generally wrapt in a coat of sandstone with calcareous cement, or covered with calcareous concretions, which betray the vestiges of recent organic remains, but show none of the older impressions, such as the belemnites and ammonites so common in Europe. The woody plain of Marānon is distinguished by the thinness of its soil, and the total absence of any calcareous ingredients, the granite approaching close to the surface, which is in some places left quite bare over an extent of many furlongs. But the Pampas of Buenos Ayres are covered to a great depth with beds of alluvial deposites, in which the powers of vegetation, fomented by the rays of a burning sun, luxuriate in wanton profusion.

The disciple of Werner traces with delight, in the majestic features of the American Continent, the same order and succession of rocks which the sagacity of that illustrious Geologist had discovered in the mountains of Saxony. Granite appears still the oldest material of our globe: To it succeeds the laminated species, or gneiss; then mica slate containing garnets; next primitive slate, with beds of native alum; now slate mixed with hornblende; above this, greenstone, or primitive trap, followed by

amygdaloid; and last of the series, porphyry slate. Resting or flanked against those primary rocks, beds of the older limestone begin to appear, followed by a suite of minerals, bearing indications of organic remains—mica slate, hornblende, gypsum, and calcareous sandstone. The only formations which Humboldt did not meet with in his extensive travels, were those of chalk, rocstone, gray-wacke, topaz rock, and the compound of serpentine with granular limestone which occurs in Asia Minor. The grand ridge of the Andes is everywhere covered with porphyry, basalt, phonolite, and greenstone; which being often broken into columns, appear at a distance like ruined castles, and produce a very striking effect. Near the bottom of that enormous chain, two different sorts of limestone occur—one with a silicious base, enclosing sometimes cinnabar and coal—and another mostly calcareous, and cementing the secondary rocks. These formations are of enormous thickness and elevation. "Beds of coal are found in the neighbourhood of Santa Fé, 8650 feet above the level of the sea: and even at the height of 14,700, near Huanco in Peru. The plains of Bogota, although elevated 9000 feet, are covered with gypsum, sandstone, shell-limestone, and even in some parts with rock salt. Fossil shells, which, in the old Continent, have not been discovered higher than the summits of the Pyrennees, or 11,700 feet above the sea, were observed in Peru, near Micuipampa, at the height of 12,800 feet; and again at that of 14,120, beside Huancavelica, where sandstone also appears. The basalt of Pichincha, near the city of Quito, has an elevation of 15,500 feet; while the top of the Schneekoppe in Silesia is only 4225 feet above the sea; the highest point in Germany where that species of rock occurs. On the other hand, granite, which in Europe crowns the loftiest mountains, is not found in the American Continent above the height of 11,500 feet. It is scarcely known at all in the provinces of Quito and Peru. The frozen summits of Chimborazo, Cayambé, and Antisana, consist entirely of porphyry, which, on the flanks of the Andes, forms a mass of 10,000 or 12,000 feet in depth. The sandstone near Cuença, has a thickness of 5000 feet; and the stupendous mass of pure quartz, on the west of Caxamarca, measures perpendicularly 9600 feet. It is likewise a remarkable fact, that the porphyry of those mountains very frequently contains hornblende, but never quartz, and seldom mica."

"The central Andes are rich beyond conception in all the metals, lead only excepted. One of the most curious ones in the bowels of those mountains is the *pacos*, a compound of clay, oxyd of iron, and the muriate of silver with native silver. The mines of Mexico and Peru, so long the objects of envy and admiration, far from being yet exhausted, promise, under a liberal and improved system, to become more productive than ever. But nature has blended with those hidden treasures the active elements of destruction. The whole chain of the Andes is subject to the most terrible earthquakes. From Cotopaxi to the South Sea, no fewer than forty volcanos are constantly burning; some of them, especially the lower ones, ejecting lava, and others discharging the muriate of ammonia, scorified basalt, and porphyry, enormous quantities of water, and especially *moya*, or clay mixed with sulphur and carbonaceous matter. Eternal snow invests their sides, and forms a barrier to the animal and vegetable kingdoms. Near that confine, the torpor of vegetation is marked by dreary wastes." (*Edin. Review*, Vol. XV. p. 233.)

We may subjoin, that, near Quito, the liquid mud ejected by the volcanos often involves myriads of small dead fish. In some parts, the mountains, like the fabled cave of Æolus, seem at times to let out their imprisoned air, and produce such furious gusts of wind as to sweep everything before them to a vast distance. In other districts, the efforts of the contending elements are betrayed, especially during the rainy season, by a doleful moaning noise, or hollow and portentous groans, enough to cast a darker shade on the gloom of superstition, and to fill the imagination of the remotest settler with secret awe and dread.

A person who, for the first time, climbs the mountains of Switzerland, is astonished to witness, in the space perhaps of a few hours, so rapid a change of climate, and such a wide range of vegetable productions. He may begin his ascent from the midst of warm vineyards, and pass through a succession of Chesnuts, Oaks, and Beeches, till he gains the elevation of the hardy Pines and stunted Birches, or treads on Alpine pastures, extending to the border of perpetual snow. But within the tropics everything is formed on a grander scale. The boundary of permanent congelation is 7500 feet higher at the equator than at the mean latitude of 45 degrees. Under a burning sun, Ananas and Plantains grow profusely near the shore; Oranges and Limes occur a little higher; then succeed fields of maize and luxuriant wheat; and the traveller has actually reached the high plain of Mexico, or the still loftier vale of Quito, before he finds a climate analogous to that of Bourdeaux or of Geneva. Now only commences the series of plants which inhabit the central parts of Europe.

But the very magnitude of the Andes appears to have the effect of diminishing the impressions of awe and wonder, which the sight of them so powerfully excites. The country on which they rest, is heaved to such a vast altitude above the sea, that the relative elevation of their summits becomes diminished in comparison with that of the surrounding amphitheatre. The majestic forms of Chimborazo, Cotopaxi, and Antisana, though 6000 feet higher than Montblanc, and clothed, like it, with eternal snow, seem to a traveller scarcely more sublime from the plains of Riobomba and Quito, than this celebrated mountain when viewed from the vale of Chamouni. It requires some time for his imagination to expand itself to the new scale of grandeur.

The central Andes, with all their magnificence, want a feature which, in the higher latitudes, contributes so much to the beauty and sublimity of the Alpine scenery. They have no vestige whatever of *Glaciers*, those icy belts dropping from the limits of congelation, and spreading in concrete sheets, or hanging in disjointed columns fantastically thrown, which occur alike in the heart of Switzerland and on the northern shores of Norway and Lapland. This defect is evidently owing to the almost uniform temperature which prevails near the equator. In

those torrid regions, the days are constantly of the same length, and the sun shines through the whole year with very nearly equal force. The limit of perpetual congelation is hence marked on the sides of the mountains of Quito with singular precision. The temperature decreases regularly in proportion as one ascends them, till at a certain altitude it comes to the point of freezing, where the permanent field of snow begins to appear, defined with an almost unvarying border. But in the higher latitudes, the sun remains, during the summer, so long above the horizon, and shines with such augmented force, that the heat of the atmosphere, and consequently of the surface of the ground, suffers a wide alteration in the different seasons. To the general investure of snow, is therefore annexed every winter, a zone of considerable breadth, which again softens and partly melts away during the continuance of the summer months. This alternate thawing and freezing, occasions the production of glaciers, by converting successively the lower detached masses of snow in the precipitous flanks of the mountains, into a collection of broken and intermingled pillars of translucid ice.

For the same reason the Andes, though torn by flaming volcanos, and convulsed by frequent and terrible earthquakes, are exempt from those *avalanches* and *eboulements* which, in Switzerland and other mountainous parts of Europe, often bury the helpless traveller in a torrent of snow, and batter down whole villages by the sudden discharge of a shower of rocks. Under the equator, the variation of temperature throughout the year is so small, as not to disturb the solidity of the vast collections of snow. But on the flanks of the Alps or Pyrennees, as the heat of the summer increases, portions of the upper field of snow become loosened, and, sliding down, put other masses likewise in motion, till spreading wider, and gaining accelerated force, the whole tide precipitates itself to the plain, sweeping all before it. Such is the accident of an *avalanche ;* but the occurrence of an *eboulement*, though less frequent, is more tremendous. When the alternation of frost and thaw detaches a mass of rock, it rolls down the side of the mountain with resistless fury, shivering into fragments and tearing everything opposed to it, overwhelming men, cattle, and houses, in one common heap of ruins.

But the Andes are distinguished from the chains of the European mountains, by frightful *quebradas* or perpendicular rents, which form very narrow vales of immense depth, whose terrific walls, fringed below with luxuriant trees and shrubs, seem to lift their naked and barren heads to the distant skies. The noted crevices of Chota and Cutaco are nearly a mile deep, the former measuring 4950, and the latter 4300 feet, in a vertical descent. The task of crossing such tremendous gullies, is often a work of infinite toil and extreme danger. In those mountainous countries, travellers are accustomed to perform their journies sitting in chairs fastened to the backs of men, called *cargueros* or *carriers*. These porters are Mulattos, and sometimes Whites, of great bodily strength and action, who will climb along the face of precipices, bearing loads of twelve and fourteen, or even eighteen stone. These *cargueros* lead a vagabond life, exposed to incredible fatigue, but recommended to them by its irregular course. Often those wretched men toil over mountains for the space of eight or nine hours every day, till, like beasts of burthen, they have their backs chafed, and made quite raw with the load. In this deplorable condition, they are not unfrequently abandoned by unfeeling travellers, and left alone to sicken, pine, or die in the forests. Yet their earnings would appear inadequate to such violent and overpowering exertions, since they receive scarcely three guineas for performing the journey from Ibague to Carthago, which requires fifteen, and perhaps twenty-five or thirty days.

The Icononzo, remarkable for its natural bridges, is a small *quebrada* or cleft of the mountains, through which flows the river of the Summa Paz, descending from the highest upland desert. The rocks consist of two different kinds of sandstone, the one extremely compact, and the other of a slaty texture, divided into their horizontal strata. The rent was probably caused by an earthquake, which the harder portion of the stony mass had resisted, and now connects the upper part of the chasm. This natural arch is 50 feet long, 40 broad, and 8 feet thick at the middle. Its height is about 300 feet above the surface of the torrent, which has a medium depth of twenty feet. About 60 feet below the natural bridge, another smaller arch occurs, composed of three slanting blocks of stone wedged together, which had probably fallen from the roof at the same instant of time, and struck against the sides of the crevice in their descent.

The natural bridge of Icononzo has perhaps no counter-part in the old world; but the writer of this article had the pleasure of seeing, in early life, a similar phenomenon, scarcely inferior to it, in the United States of America. We allude to the famous arch, described by Mr Jefferson, which crosses the Cedar Creek in Rockbridge county, about an hundred miles beyond the Blue Ridge, in the higher district of Virginia. The divided rock is a pure limestone, leaving a chasm about 90 feet wide, of which the walls are 230 feet high, sprinkled with verdant bushes, and enamelled with gay flowers, among which the *aquilegia* is conspicuous. This bridge, viewed from a little distance below, has all the appearance of a Gothic arch ; and is of such solidity, that loaded waggons used formerly to pass along it, till a more convenient line of road was formed.

In some places, the natives of Peru connect the clefts of their mountains by pendulous bridges thrown fearlessly across, and suspended from both sides of a gap. They are formed of ropes made of the tough fibres of the *agavé*, hanging in a gentle parallel curve, and covered with reeds or canes, with occasionally a narrow border of basket-work. The intrepid Indian, regardless of the horrors of the unfathomed abyss which yawns from below, commits himself to his frail and floating arch, and swiftly glides along its bending curvature, till he gains the opposite bank.

The Andes likewise give rise to waterfalls of immense height and amazing force. The cataract of Tequendama, considered in all its circumstances, exceeds any other in the known world. The basin

which feeds its streams is the vast plain of Bogota, 7465 feet above the level of the sea, encircled completely with lofty mountains, except where the water, aided probably by the concussion of an earthquake, has cut for itself a narrow passage. The river Funcha, swelled by numerous feeders, gradually contracts its channel to the breadth of about 40 feet, and then gathering augmented force, dashes at two bounds from a perpendicular height of near 600 feet, into a dark gulf. Owing to the excessive rapidity and depth of its current, it must discharge a prodigious volume of water, which quite stuns the ear by the roar of its crash; while it raises enormous clouds of thick spray and vapour, that continually bedew, and perhaps quicken the vegetation of the adjacent grounds. Everything conspires to exalt the beauty and grandeur of the scenery. "Independent of the height and mass of the column of water," says Humboldt, "the figure of the landscape, and the aspect of the rocks, it is the luxuriant form of the trees and herbaceous plants, their distribution into thickets, the contrast of those craggy precipices, and the freshness of vegetation, which stamp a peculiar character on these great scenes of nature." The transition from a temperate to a warm climate is rapid and surprising. The plain of Bogota bears rich crops of wheat, then succeed Oaks and Elms, intermingled with Aralias, Begonias, and the Yellow-bark trees; but, immediately below the cataract, a few Palms appear, as if it were to mark the advance to a sultry soil.

A lively idea of the character and grand features of the Andes may be conceived from the account which the celebrated Humboldt has given of his journey across that majestic chain. Our readers will be glad to peruse it in the author's own words:

"The mountain of Quindiu, in the latitude of 4° 36′, is considered as the most difficult passage in the Cordilleras of the Andes. It is a thick uninhabited forest, which, in the finest season, cannot be traversed in less than ten or twelve days. Not even a hut is to be seen, nor can any means of subsistence be found. Travellers, at all times of the year, furnish themselves with a month's provision, since it often happens, that, by the melting of the snows, and the sudden swell of the torrents, they find themselves so circumstanced, that they can descend neither on the side of Carthago, nor that of Ibague. The highest point of the road, the Garito del Paramo, is 11,500 feet above the level of the sea. As the foot of the mountain, towards the banks of the Cauca, is only 3150 feet, the climate there is generally mild and temperate. The pathway, which forms the passage of the Cordilleras, is only 12 or 15 inches in breadth, and has the appearance, in several places, of a gallery dug, and left open to the sky. In this part of the Andes, as almost in every other, the rock is covered with a thick stratum of clay. The streamlets which flow down the mountains have hollowed out gullies about 20 feet deep. Along these crevices, which are full of mud, the traveller is forced to grope his passage; the darkness of which is increased by the thick vegetation that covers the opening above. The oxen, which are the beasts of burden commonly used in this country, can scarcely force their way through these galleries, some of which are more than a mile in length; and if, perchance, the traveller meets them in one of these passages, he finds no means of avoiding them, but by turning back, and climbing the earthen wall which borders the crevice, and keeping himself suspended, by laying hold of the roots which penetrate to this depth from the surface of the ground."

"We traversed the mountain of Quindiu in the month of October 1801, on foot, followed by twelve oxen, which carried our collections and instruments, amidst a deluge of rain, to which we were exposed during the last three or four days, in our descent on the western side of the Cordilleras. The road passes through a country full of bogs, and covered with Bamboos. Our shoes were so torn by the prickles which shoot out from the roots of these gigantic gramina, that we were forced, like all other travellers who dislike being carried on men's backs, to go barefooted. This circumstance, the continual humidity, the length of the passage, the muscular force required to tread in a thick and muddy clay, the necessity of fording deep torrents of icy water, render this journey extremely fatiguing; but however painful, it is accompanied by none of those dangers with which the credulity of the people alarm travellers. The road is narrow, but the places where it skirts the precipices are very rare."

"When travellers reach Ibague, and prepare to cross the forests of Quindiu, they pluck in the neighbouring mountains, several hundred leaves of the Vijao, a plant of the family of the Bananas, which forms a genus approaching to the Thalia, and which must not be confounded with the *Heliconia Bibai*. These leaves, which are membranous and silky, like those of the *Musa*, are of an oval form, two feet long and 16 inches broad. Their lower surface is a silvery white, and covered with a farinaceous substance which falls off in scales. This peculiar varnish enables them to resist the rain during a long time. In gathering these leaves, an incision is made in the middle rib, which is the continuation of the foot-stalk; and this serves as a hook to suspend them, when the moveable roof is formed. On taking it down, they are spread out, and carefully rolled up in a cylindrical bundle. It requires about an hundred weight of leaves to cover a hut large enough to hold six or eight persons. When the travellers reach a spot in the midst of the forests where the ground is dry, and where they propose to pass the night, the cargueros lop a few branches from the trees, with which they make a tent. In a few minutes, this slight timber work is divided into squares, by the stalks of some climbing plant, or the threads of the agave placed in parallel lines, 12 or 13 inches from each other. The Vijao leaves meanwhile have been unrolled, and are now spread over the above work, so as to cover it like the tiles of a house. These huts, thus hastily built, are cool and commodious. If, during the night, the traveller feels the rain, he points out the spot where it enters, and a leaf is sufficient to obviate the inconvenience. We passed several days in the valley of Boquia, under one of those leafy tents, which was perfectly dry, amidst violent and incessant rains."

For farther information relative to the structure of the Andes, see the various sketches given by Humboldt, and particularly an abstract of his Geological Observations inserted in the *Journal de Physique*, Vol. LIII. for 1801. (D.)

ANDREWS (JAMES PETTIT), a late English historian and miscellaneous writer, was the younger son of Joseph Andrews, Esq. of Shaw-house, near Newbury, Berks, where he was born in the year 1737. He was educated privately, and is said to have discovered an early taste for literature and the fine arts. He joined the Berkshire militia when they were first called out, being then about 18 or 19; and held the rank of lieutenant in that regiment, until it was disbanded. On the institution of the new system of London Police, he was appointed one of the Commissioners for the district of Queen's Square and St Margaret's, Westminster, and discharged the duties of that office, with great industry and integrity, until his death, which took place at his house in London, on the 6th of August 1797, in the 60th year of his age. He married Miss Anne Penrose, daughter of the Reverend Mr Penrose, late rector of Newbury, by whom he had two sons and a daughter. He seems to have possessed a cheerful and social disposition, and enjoyed the conversation of a large circle of literary acquaintance, who frequently met at his house and experienced his hospitality.

Mr Andrews appears to have devoted a considerable portion of his time to literary pursuits; and he is the author of several works which are not undeserving of notice. The first publication upon which we find him employed, is an edition of the poems of his friend and relation, Penrose, in 1781; to which he prefixed an introduction, containing a short account of the life and character of the author. His first original production, so far as we have been able to ascertain, was a pamphlet in behalf of the chimney-sweepers' apprentices, in 1788; which is said to have led to the act of Parliament, passed not long afterwards, for the purpose of ameliorating the condition of that unfortunate class of beings. In 1789, he published *Anecdotes, ancient and modern*, 8vo; a work of pleasantry, in the composition of which, he acknowledged having received assistance from the late Laureat, Mr Pye, the facetious antiquary, Captain Grose, and others. To this volume he added a supplement, in 1790.

The most extensive work undertaken by Mr Andrews, was his *History of Great Britain, connected with the Chronology of Europe; with Notes*, &c. The first volume, which commences with Cæsar's invasion, and ends with the deposition and death of Richard II. was published in 1794, in 4to. A second volume, in which the history is continued from the deposition and death of Richard II. to the accession of Edward VI. appeared in 1795. The plan of this work is new, and in some respects singular; a certain portion of the history of England is given on one page, and a corresponding portion of the contemporaneous history of Europe on the one opposite. The notes consist of a variety of curious and amusing particulars, not immediately connected with the main story. Appendixes are also added, at proper intervals, containing an account of the state of literature, science, religion, government, manners, &c. at different periods. The author, however, did not live to complete this curious and extensive work; no more of it having appeared than the two volumes above mentioned. In 1796, he published a continuation of Henry's *History of Britain*, in one volume 4to, and two volumes 8vo.



The other productions of this author are, *An Account of Saxon Coins found in Kintbury Church-yard, Berks*, printed in the 7th volume of the *Archæologia*; the *Account of Shaw*, in Mr Mores's Berkshire collections; *The Savages of Europe*, a popular French novel, which he translated, and illustrated by prints from his own designs. Mr Andrews was also a frequent contributor to the *Gentleman's Magazine*. See the *Gen. Biog. Dict.* by Chalmers; *Introduction to "Poems by the Rev. Thomas Penrose,"* 1781; *Gent. Mag.* for 1797 and 1801; and Lysons' *Supplement to Environs of London*. 1811. (H)

ANEMOMETER, ANEMOSCOPE. See these Articles in the *Encyclopædia*, and WIND-GAGE in this Supplement.

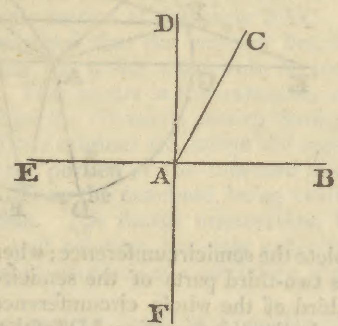
ANGLE. This term is, owing to the poverty of language, employed to signify very different things. In Plane Geometry, it means the opening or separation of two straight lines which meet in a point; but in Solid Geometry, it variously denotes the deviation of a straight line from a plane, the divergencies of one plane from another at their line of junction, or even a cluster of plane angles terminating in a common summit. This diversified application of the same word is not likely, however, among mathematicians, to occasion any misconception. But it would be more perspicuous, and certainly more philosophical, to imitate the practice of naturalists in framing a set of cognate words to express the several transitions of meaning.

The word *angle* was drawn from common discourse into the vocabulary of science. Its primitive sense in all the languages in which it can be traced, is merely a *nook* or *corner*; but it has acquired a more precise and extensive application in its transfer to geometry. In its simplest form, it now denotes generally the *divergence* or difference of direction between two concurring straight lines. Yet a learner still experiences some difficulty in seizing the correct idea of its nature, which has always baffled the attempts of authors to reduce to the terms of a strict definition. Apollonius, at once the most elegant and inventive of the Greek geometers, was satisfied with representing an angle as a *collection of space about a point*; a description which is not only extremely loose, but which intimates quite a different conception. Euclid, the great compiler of the *Elements*, has defined an angle to be the κλισις, *or mutual inclination of two straight lines that meet*. But, in strict language, this definition should apply only to the acute angle, in which one of the sides leans towards the other, and deflects from the perpendicular. Without an extension of the meaning of the term *inclination*, it will not include the obtuse angle, and far less comprehend angles in general; which, since they are capable of repeated additions, must evidently, as much as lines themselves, be susceptible of all degrees of magnitude.

Nature of.

It is indeed impossible, by any combination of words, to express completely and accurately, the primary notions which form the ground of geometrical science. The more profitable task is to trace the process by which the mind, refining on external observation, comes to acquire such abstract ideas. We seem to get the idea of *length* or of *linear extension,* by viewing progressive motion; and the enlarged conception of *angles* or of *angular magnitude* is easily attained, from the contemplation of revolving motion. In opening, for instance, the legs of a pair of compasses, we perceive that their difference in direction gradually increases, keeping pace with the turning at the joint. The quantity of this opening properly constitutes the measure of an angle; and an entire revolution, which brings the moving side of the angle back to its first position, furnishes a standard of reference. The revolution bisected, marks the divergence of a directly opposite position, or that of two segments of a straight line at their point of separation; and the half of this again, or the divergence of a line proceeding from the same point, and turned equally aside from both segments, is the right angle, which, therefore, being constant, serves to measure all the rest.

Suppose an inflexible straight line AB to turn from right to left, about the point or vertex A. It first comes to the position AC, then to AD, next to AE, now it reaches AF, and lastly it gains its original site AB.

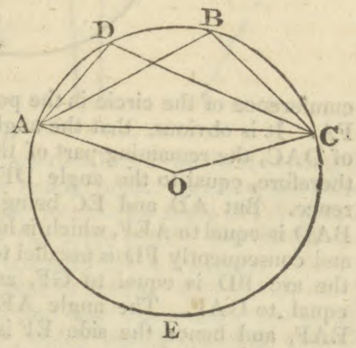



The angles thus formed at the point A, arise from the combination of successive openings. The angle BAD is composed of BAC and CAD, the angle BAE, or that of direct opposition, is compounded of BAC, CAD, and DAE, and the entire circuit is made up of the accumulated angle BAC, CAD, DAE, EAF, and FAB. This circuit being quartered by the straight lines BE and DF, is divided at the vertex A into four right angles. By comparison, therefore, the angle BAC is acute, and CAE obtuse.

But the side AB can attain the direction AC, either by moving onwards, or by turning backwards through the points F, E, and D. The angle compounded of the openings BAF, FAE, EAD, and DHC, may hence be termed appropriately the *reverse* of BAC. The defect of an angle from a right angle is called its *complement*, the defect from two right angles its *supplement*, and the defect from four right angles or the entire circuit, might be conveniently named its *explement*. Thus, CAD is the *complement* of the angle BAC, CAE is its *supplement*, and the reverse angle BAC its *explement*.

If we consider attentively the formation of angles about a point, we shall be convinced that two concurring straight lines do not contain merely a single angle, but involve an indefinite multitude of angles; in short, that they comprehend all the revolutions and parts of a revolution by which the one line would successively attain the direction of the other. Hence AB will, after describing repeated revolutions, always return into the same position AC. Thus, if A represent the measure of an angle, and C that of a whole circuit or four right angles; then the primary angle will include likewise A+C, A+2C, A+3C, A+4C continued for ever. Of those successive angles, A, A+C, A+2C, A+3C, A+4C, &c. &c. the sines, tangents, and secants, are severally the same; and so are the versed sines, the cosines, cotangents and cosecants. This extension of the doctrine of angles, is of the greatest importance in the higher branches of geometry, in the application of trigonometrical formulæ, and in algebraical analysis.

Euclid, in the course of his reasoning, has frequent occasion to combine angles together; and yet he never ventures beyond the consideration of those angles which are less than two right angles. Had he composed his *Elements* after the science of trigonometry came to be cultivated, he could not have failed to take more enlarged views of angular magnitude. In consequence of his narrow conception of the constitution of angles, the Greek geometer is not a little cramped sometimes, and obliged to adopt a circuitous mode of demonstration. For instance, in the 20th prop. of his third book—that "the angles at the circumference are the halves of those at the centre standing on the same arc,"—he quite overlooks the case of obtuse angles at the circumference. But, in the annexed figure, the angle ABC is clearly the half of the *reverse* angle AOC at the centre, which is subtended by the large arc AEC. It hence follows that the obtuse angles ABC and ADC contained in the same segment must be equal, since they are both of them halves of the *reverse* angle AOC. Yet, in demonstrating this very obvious corollary, Euclid is constrained to divide the obtuse angles into portions which are shown to be the halves of corresponding angles at the centre. For the same reason, he finds it necessary to give a distinct demonstration of the celebrated proposition that "the angle contained in a semicircle is a right angle." But this property ought likewise to be considered as a simple corollary, for if radii OA and OC were supposed to extend in one straight line, and thus form the diameter of the circle, their angle AOC would become equal to two right angles, and consequently ABC its half would be one right angle. See *Leslie's Geometry.* (D.)



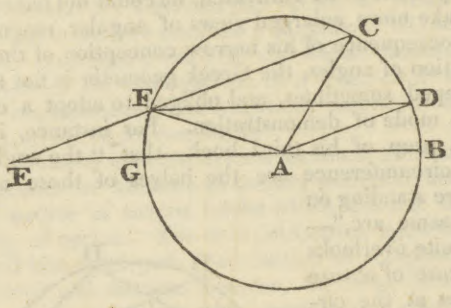

ANGLE (Trisection of). The attempts of the Greek mathematicians to *Double a Cube* and to *Trisect an Angle,* were their first steps beyond the limits

Trisection of.

of Elementary Geometry. They soon perceived that such problems cannot be solved by any combination of mere straight lines or circles. To this conclusion they were led directly by the application of *Geometrical Analysis*, a beautiful instrument of discovery which Plato had recently invented or improved. Their investigations pointed at some curves of a higher order than the circle, and opened to them a wide and interesting field of research.

The analysis of the trisection of an angle, conducted in two different ways, terminates in the construction of the *Conchoid*, a complex curve which was first proposed by Nicomedes. As the subject is very curious, and throws great light on the theory of angular magnitude, we shall here not only give both the ancient methods of investigation, but subjoin a third which is due to the sagacity of Newton.

1. Let it be required to trisect the angle BAC or the arc BC. Suppose the thing already done, and the angle BAD to be the third part of the given angle. From the point CE draw CE parallel to AD, meeting the extended diameter in E, and cutting the cir-

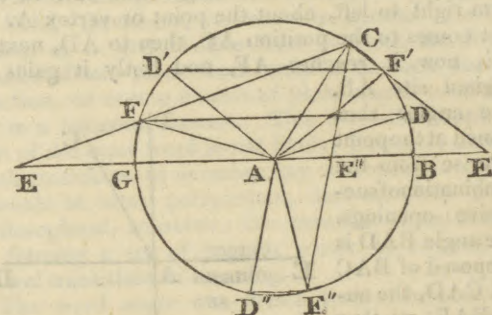



cumference of the circle in the point F; join FD and FA. It is obvious, that the angle BAD is the half of DAC, the remaining part of the whole angle, and therefore, equal to the angle DFC at the circumference. But AD and EC being parallel, the angle BAD is equal to AEF, which is hence equal to DFC; and consequently FD is parallel to EB. Wherefore, the arc BD is equal to GF, and the angle BAD equal to GAF. The angle AEF is thus equal to EAF, and hence the side EF is equal to AF, the radius of the circle.

To solve the problem, therefore, it would be requisite to inflect from C a straight line CFE, such that the portion FE, intercepted between the circumference and the diameter or its extension, should be equal to the radius of the circle. The radius AD, drawn parallel to this inflected line, CE would cut off an angle BAD, which is the third part of the given angle BAC.

But it is clear, that Elementary Geometry will not furnish the means of inflecting CE, according to the required conditions. This must be done either tentatively, that is, by repeated trials, or by the application of a curve, so constituted, that every straight line drawn from the *pole* C, to the *directrix* BG, shall have the portion EF, intercepted by the curve equal to AB. This curve is, from its general shape or resemblance to a *conch* or shell, named the *Conchoid;* consists of two branches, one above the directrix called the *interior conchoid*, and the other below it, called the *exterior conchoid*. The conchoid being described, will, by its intersection with the circumference of the circle, give the point F, and consequently the position of trisecting line AD′. But such a complex curve must cut the circumference in more points than one, and consequently the problem of angular trisection, viewed in its generality, admits of several answers. In fact, there are always *three* distinct positions of the inflected line CE, which will fulfil the conditions of the problem

It is curious to examine these different positions of the inflected line. Draw AD′ parallel to the *second* position CE′, and join D′F′, AD′, and AF′. Because AF′ is equal to E′F′, the angle E′AF′ is equal to AE′F′; and, consequently, the exterior angle AFC is the double of either of these. But CAF′ being an isosceles triangle, AF′C is equal to ACF′, which again is equal to the alternate angle CAD′; wherefore, CAD′ is the double of the angle AE′F′; and being likewise the double of CF′D′ at the circumference, the angles CF′D′ and AE′F′ are equal; and, consequently, F′D′ and E′A parallel. Now the angle CAD′ being double of E′AF′ or D′AG, and the angle CAD double of DAB, the arc DCD′ is double of the arcs D′G and DB, which serve to com-




plete the semicircumference; wherefore, this arc DCD′ is two-third parts of the semicircumference, or one-third of the whole circumference.

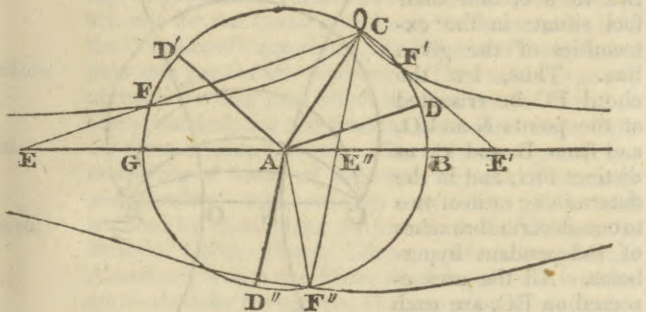
In the *third* position AD″ of the trisecting line, draw CF″ parallel to it, and join AF″ and D″F″. The isosceles triangles D″AF″ and AF″E″ have equal vertical angles; and, consequently, the angles at their base are likewise equal; wherefore, AF″D″ is equal to the alternate angle F″AE″, and the chord D″F″ parallel to the diameter BG. But the reverse angle CAD″, standing on the arc CD′D″, is double of the angle CF″D″ at the circumference, and, therefore, double of BE″F″ or of BAD″; and the angle CAD being, by the first construction, likewise double of BAD, the reverse angle CAD″, together with CAD, must be double of BAD″ and BAD, or the arc CD′GD″ is double of DBD″, which completes the circumference. Hence the arc DD′D″ is two-thirds of the circumference.

It thus appears that the construction of the problem assumes three different aspects, and that the trisecting lines, to which a close analogy conducts us, mutually divide the whole circuit into equal portions. These results are perfectly conformable with the theory of angular magnitude. For if A denote the arc BC, and C the whole circumference, this arc

Trisection of.

will be generally expressed by A, A+C, A+2C, &c.; consequently, the third part will be expressed by $\frac{1}{3}$A, $\frac{1}{3}$A+$\frac{1}{3}$C, $\frac{1}{3}$A+$\frac{2}{3}$C, &c., which evidently correspond to BD, BD′ and BD″. But any farther extension of this progression only brings the trisecting line back into its former positions.

To solve completely, therefore, the problem of the trisection of an angle, from the pole C, on either side of the directrix BG, with a measure equal to the radius of the circle, describe the exterior and the interior or nodated conchoid; draw CF, CF′ and CF″ to the three points of intersection with the circumference,

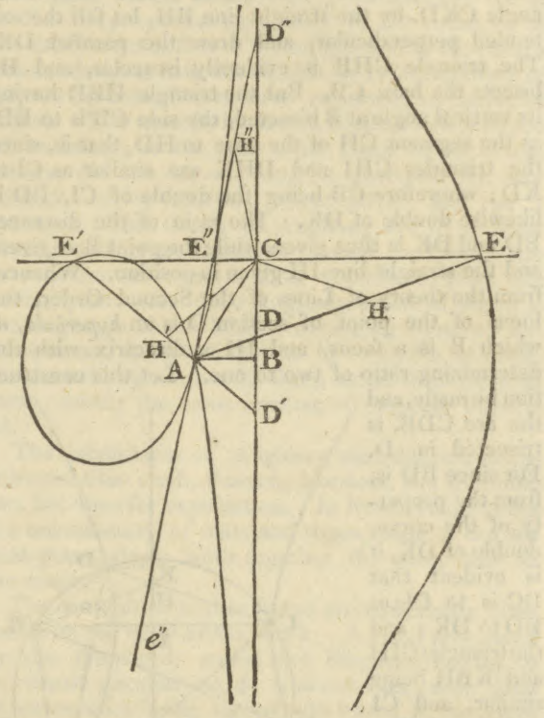



and the radii AD, AD′, and AD″, parallel to these will mark the triple section of the angle BAC.

It may be perceived that the exterior branch of the conchoid cuts the under semicircle in another point besides F. This occurs in the extension of the radius CA, or where the diameter, passing through C, the extremity of the original arc, meets the opposite circumference; the portion of the inflected line, intercepted below BG by the conchoid, being evidently equal to the radius. The fourth intersection, however, affords no real solution, but only exhibits the amount of repeated division, as completing the arc itself.

2. But another analysis leads to a similar result. Let the angle BAD as before be third part of BAC; draw BC perpendicular to AB and CE parallel to it, meeting AD produced in E. The right angle DCE would be contained in a semicircle having DE for its diameter; join C with the centre H, and the triangle CHE being isosceles, the exterior angle CHA is double of CEH, or of the alternate angle BAD: and, therefore, equal to the remaining portion CAD of the divided angle BAC. Whence the triangle ACH is isosceles, and the side CH equal to HC, or the diameter DE must be double of AC.

The construction of the problem is thus reduced to the drawing from the vertex to the given angle, a straight line, ADE, such that the part DE intercepted between the perpendiculars BC and CE, shall be equal to the double of AC. This can only be done by describing a conchoid from the pole A to the directrix BC, and with the double of AC as the measure; the intersection of the curve with the perpendicular CE, will determine the position of the trisecting line ADE. The exterior branch of the conchoid, will cut the perpendicular in the point E, and the interior or nodated branch will meet and cross it at the two points E′ and E″. The radiating lines AE, AE′, and AE″, or its extension A$e$″, will indicate the complete trisection of the angle BAC. These lines will be found, as in the first construction, to make angles with each other that are equal to the thirds of an entire circuit. It may be worth while to examine the several cases.



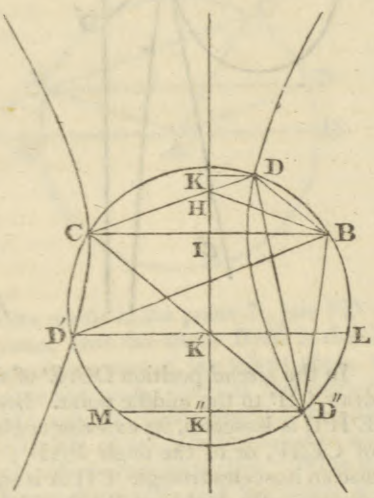

In the *second* position D′AE′ of the trisecting line, draw CH′ to the middle point. Because the triangle E′H′C is isosceles, its exterior angle CH′A is double of CE′H′, or of the angle BAD′; but H′CA being also an isosceles triangle, CH′A is equal to CAH, and consequently double of BAD. Add CAD, which is double of BAD, and the compound angle DAE′ is double of DAD′, which would complete two right angles; whence DAE′ is two-thirds of two right angles, or one-third of a whole circuit.

In the *third* position, AE″D″ of the trisecting line, or rather its extension A$e$″, draw CH″ to bisect E″D″. The triangles CH″D and ACH″ are then isosceles, and consequently the angle CAD″ or CH″A is double of CD″A; but CAE is likewise double of CEA, and therefore the combined angle D″HE is double of the angles CD″A and CEA. Now this angle D″HE, together with the two angles CD″A and CEH, is evidently equal to the exterior angle DC″E or a right angle. Whence D″AE is two-thirds of a right angle, or one-third of two right angles, and therefore the adjacent angle DAE″ is two-thirds of two right angles, or one-third of a whole circuit.

3. The simplest and most elegant solution of the trisection of an arc is due to modern science, and first appeared in Newton's *Universal Arithmetic*.

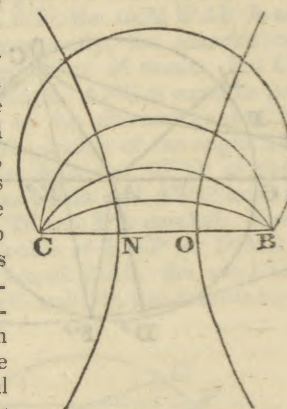
Trisection of.

The problem is there reduced to the combination of the circle with a certain kind of hyperbola. But the general property of the directrix, which belongs to all the conic sections, or the lines of the second order, affords the readiest mode of investigation. Let the arc BD be the third part of BDC. Complete the circle, and draw the chords BD, BC, and CD. The arc CD is evidently double of BD, and therefore, the angle CBD is double of BCD. Bisect the angle CKD, by the straight line BH, let fall the extended perpendicular, and draw the parallel DK. The triangle CHB is evidently isosceles, and HI bisects the base CB. But the triangle HBD having its vertical angle at B bisected, the side CB is to BD, as the segment CH of the base to HD, that is, since the triangles CHI and DHK are similar as CI to KD; wherefore CB being the double of CI, BD is likewise double of DK. The ratio of the distances BD and DK is thus given, while the point B is given, and the straight line IH given in position. Whence, from the theory of Lines of the Second Order, the locus of the point of section D is an *hyperbola*, of which B is a focus, and IH a directrix, with the determining ratio of two to one. Let this construction be made, and the arc CDB, is trisected in D. For since BD is, from the property of the curve, double of DK, it is evident that BC is to CI as BD to DK; and the triangles CIH and KBH being similar, and CI to CH, as DK to DH, it follows that BC is to CH as BD to DH, or alternately BC is to BD as CH to DK. Wherefore the vertical angle CBD is bisected by BH, or the angle CBD is double of CBH or of BCD; and consequently the arc CD is double of BD, or BD itself is the third part of the whole arc CDB.

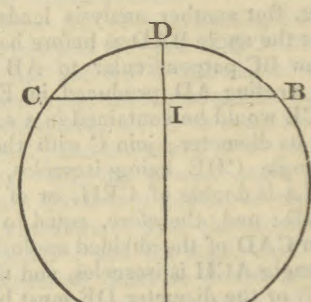



But the opposite branch of the hyperbola, which passes through C, also comes into play; and the intersection of these two branches with the circle, assigns three different positions of the point D, separated from each other by intervals equal to the third of the whole circumference. Thus, in the *second* position D′, produce the perpendicular D′K′ to the opposite circumference L; and since BD′ is double of D′K, it must be equal to the chord D′L, and consequently the arc BDCD′ is equal to D″MD′. Wherefore the double of BDCD′, together with the interval BL or CD, is equal to the whole circumference; that is, the double of DCD′ with the double of BD and CB′ is equal to the whole circumference; and since the double of BD is DC, the triple of the arc DCD′ must complete the circumference. In the *third* position D″, produce the perpendicular DK″ as before; the double of this or the chord BD″ is hence equal to D″M, and the arc BLD″ equal to DM. Consequently the double of BLD″, with the compound arc, BDCM completes the circumference; but D″M, being parallel to BC, the arc BLD″ is equal to CD′M, and therefore three times the arc BLD″ with the arc BDC, or the triple of BD will fill up the circumference, or the arc DBD″ is a third part of it.

The trisection of innumerable arcs described on the same chord is rendered very conspicuous, by combining the separate branches of two hyperbolas that have the determining ratio of two to one, and their foci situate in the extremities of the given line. Thus, let the chord BC be trisected at the points N and O, and from B and C, as distinct foci, and in the determining ratio of two to one, describe branches of independent hyperbolas. All the arcs erected on BC, are each of them divided by those curves into three equal portions. These arcs, as they flatten, approach to the trisected chord CNOB, on the one hand; and as they become enlarged, they constantly tend, on the other, to the complete circumference which the asymptotes of the hyperbola, making angles on each side of the axis equal to two-thirds of a right angle, would themselves trisect.




It may be observed in general, that the section of an arc or angle admits of as many different answers as the number of divisions proposed. Thus, the quadrisection would give four distinct results, and a quinsection would involve no fewer than five separate products. Nay, the bisection itself of an arc, though within the limits of the most elementary geometry, yet brings out a double result. Thus, the arc CDB is bisected by perpendicular or diameter DID′, which not only gives BD for the half of that arc, but also BDCD′, or the same half arc augmented by a semicircumference.




These conclusions agree with the results derived from the general theory of functions. The expression for the sine of a multiple arc, is always an equation of corresponding dimensions; which therefore admits of as many distinct roots as the index contains units.

(D.)

Anglesey.

Extent and Divisions.

ANGLESEY, the Mona of Tacitus, and Tir-mon of the Welsh, is of an irregular form, and indented on three of its sides with numerous small bays and creeks; its length from Carnets point to Bangor ferry is 20 miles, and its greatest breadth from Llanddwyn Abbey to Penmon Priory, 17 miles; its area, by the most recent and accurate survey, comprises 173,000 acres. At the time when Wales was divided into six Counties by Henry VIII. this Island, which formed one of them, was subdivided into three Hundreds; at present it contains six Hundreds. In it there are four market towns, Beaumaris (the County town), Newborough, Llanerchymedd, and Holyhead; and 74 parishes. It returns two members to Parliament, viz. one for the County, and one for Beaumaris; is in the Province of Canterbury, and Diocese of Bangor, and pays one part of the land-tax. The surface is gently undulated; that part which borders on the Menai is finely wooded, but the interior is a naked tract without trees or even hedges. The soil is nearly uniform, consisting of loam of different degrees of tenacity and fertility, with scarcely any clay. It is well watered by 12 rivulets, the principal of which are the Braink, Cefni, Ffraw, Llivon, and Allon. Near Aberffraw, where the Ffraw discharges itself into the sea, is the lake Llyngoron, about two miles in circumference, abounding in trout, gwyniaid, and other fish. There is undoubted evidence of the encroachment of the sea on the shore of this Island: the Lavan sands, in the bay of Beaumaris, formed a habitable Hundred in the sixth century, when they were suddenly overwhelmed by the sea. There are five ferries across the Menai Straits, of which Port-hamel, or the Gloomy ferry (so called from the dense woods which in former times overshaded its banks), is celebrated as the place, where Suetonius landed, when he exterminated the Druids. Off the eastern point is the steep, rocky islet of Priest-holme, or Puffin's island: it is a noted resort, during the summer, of various birds of passage; the Puffin, whence it derives one of its appellations, breeds there in immense numbers. At the northern point of Anglesey, is the isle of Seals; its sides are frequented by vast shoals of fish, and Seals which prey upon them.

Surface.

Soil.

Rivers.

Minerals.

Anglesey is rich in minerals, particularly in copper. Of the mines of this metal in the Parys mountain, a particular account is given in the body of the work, on the authority of Mr Pennant; since that account was written, the produce of these mines has declined considerably; the number of men employed having been reduced, from 1500 to 600. Besides common limestone, white marble, and blue-veined grey marble, sulphat of barytes, an earth yielding $\frac{2}{7}$ of pure magnesia, steatite, serpentine, fullers earth, and native sulphur, are found in this Island. Hitherto, coal has not been wrought with any profit, though the depth of coal, in proportion to the whole depth sunk, appears favourable, being $3\frac{1}{2}$ feet in 77 feet. An uncommon appearance in the natural history of this fossil is met with in Anglesey, viz. podicles of loose coal of several tons weight. This Island is celebrated for the variety of its shell-fish; Bingley, in his tour, gives a list of thirty-eight of the principal of these productions; the oysters in particular are highly esteemed. The botany of Anglesey presents nothing very peculiar or remarkable.

Anglesey || Annealing.

Agriculture.

Of the 173,000 acres contained in Anglesey, it is computed that there are 12,600 acres of waste land; and that no more than the eleventh part of the remainder is under tillage, in the following proportions; oats 7953 acres; barley 6107; wheat 520; rye 2. In the *Encyclopædia*, apparently on the authority of the anonymous author of the supplement to Rowland's *Mona Antiqua*, it is stated, that in 1770, upwards of 90,000 bushels of corn were exported, exclusive of wheat. This must be incorrect, as the whole produce of the Island, in the year 1795, taken by an actual survey, did not exceed 59,770 quarters; viz. oats 35,485; barley 22,700; wheat 1578; and rye 7 quarters. The Cattle of Anglesey are of a good breed; and great attention is paid to them; the average annual export is about 8000 head, from one to four years old. The Anglesey breed of sheep is the largest in North Wales; averaging about 15 lbs. the quarter, and yielding from $1\frac{3}{4}$ to $2\frac{1}{2}$ lbs. of wool: the annual exportation of sheep varies from 5000 to 7000; nearly the same number of hogs are exported.

Manufactures.

The inhabitants of Anglesey manufacture deep-coloured blue cloth, flannels, blankets, &c. for home use, but none for exportation. In Newborough there is a manufacture of mats and ropes, made of the sea reed-grass, which binds together the sandy hills on the coast.

Antiquities.

The antiquities of this Island are sufficiently illustrated in the body of the work. A rural pipe, used by the Shepherd, called the Pibgorn, is said to be almost peculiar to it; it derives its name from its extremities being tipped with horn; it has seven holes, besides the aperture in which the reed is concealed; and its tone is between the flute and the clarionet.

Population.

From the population returns of 1801, it appears that there were then in Anglesey 6679 houses, inhabited by 7058 families; and 127 uninhabited houses; 9776 *persons* chiefly employed in agriculture: 2614 in manufactures and trade; and 19,228 not comprised in these two classes: the number of males was 15,775; and of females 18,031. By the returns in 1811, there were 7183 houses, inhabited by 7706 families; 72 houses building; 108 uninhabited; 5376 *families* chiefly employed in agriculture; 1453 in manufactures; and 877 not comprised in these two classes: the number of males was 17,444; and of females 19,601. It will be remarked, that, according to both returns, the number of females exceeds that of males; this disproportion is not, however, peculiar to Anglesey, but extends over all Wales.

The reader, who is desirous of farther information, in regard to this Island, may consult Davie's *General View of the Agriculture of North Wales.*—Bingley's *Tour in North Wales.*—A. Aiken's *Tour in Wales.* (c.)

ANNEALING. The nature and use of this process in Glass-making, has been already explained in

Annealing. the body of the work; it remains to add some details in regard to its application to metals. In the manufactures, in which the malleable metals are employed, annealing is used to soften a metal after it has been rendered hard by the hammer, and also to soften cast-iron, which is rendered very hard and brittle by rapid cooling.

In the manufacture of steel goods, which are first formed by the hammer, and require to be filed or otherwise treated, and in which softness and flexibility are essential to the change, annealing is absolutely necessary. This is particularly the case in making files and scissors; that the metal may be left sufficiently soft for cutting the teeth, and for filing off those parts which cannot be ground. Annealing is not less necessary in the drawing of wire, whether iron, copper, brass, silver, or gold. The operation of drawing soon gives the wire a degree of hardness and elasticity, which, if not removed from time to time by annealing, would prevent the extension of the wire, and render it extremely brittle. The same operation is also necessary in rolling or flatting those metals which are in a cold state, such as brass, silver, gold, &c. The Brazier who forms vessels of copper and brass by the hammer, can work upon it only for a little time, before he is obliged to anneal it.

The common methods employed for annealing iron and steel are very injudicious, and materially injure the latter, when it is used for making cutting instruments. After they have been formed by the hammer, they are generally piled up in an *open* fire, slowly raised to red heat, and then allowed as gradually to cool. By this method, the surface of the steel will be found considerably scaled, from the action of the oxygen of the atmosphere. When it is remembered, that steel consists of iron joined to carbon, it will be evident, that the steel immediately under the scaly oxyd will be deprived of its carbon, which has been carried off by the attraction of the oxygen; and in consequence, will lose the property, of acquiring that degree of hardness necessary to a cutting instrument.

Nothing, therefore, can be more obvious, than that steel particularly should be annealed in close vessels, to prevent that effect. For this purpose, the goods should be placed in a trough or recess made of fire-stone, or fire-brick, and stratified with ashes, or clean sand, and finally covered with a thick stratum of the same; but if the size of the vessel be small, it may have a cover of its own materials. This oven or trough must now be heated by the flame of a furnace passing under and round it till the whole is of a red heat. It must then be suffered to cool, without letting in the air. The goods so treated, will be much softer than by the common method. The surface, instead of becoming scaled, will have acquired a metallic whiteness, from the presence of a small quantity of carbonaceous matter contained in the ashes in which they were imbedded. They will become so flexible also, as to allow them to bend considerably without breaking, which is very far from being the case before the operation. The fracture, before annealing, will be smooth and short; but afterwards it will be rough, exhibiting bright parts of a crystalline appearance. Wire, especially that of iron and steel, should be treated in a similar way, when it is annealed. The wire used for some purposes, requires to be soft, and is sold in that state. If the wire after finishing, when it is bright and clean, were to be annealed in contact with oxygen, it would not only lose all its lustre and smoothness, but much of its tenacity. The process above-mentioned will therefore be particularly necessary in annealing finished wire, as well as in softening it from time to time during the drawing.

Copper and brass suffer much less than iron and steel from annealing in the open air, and do not require to be heated above a low red heat. If, however, the lustre is to be preserved, a close vessel would be desirable. The latter metals, after annealing, although much discoloured by the oxygen of the atmosphere, may be cleansed, by immersion in a hot liquor composed of water and a small quantity of sulphuric or nitric acid. Very small brass or copper wire is frequently annealed, by exposing it to the flame of hay or straw. In casting minute pieces of pig-iron, which is generally done in wet sand, the metal possesses the property of steel to such a degree, as to assume, by the rapid cooling, a degree of hardness equal to hardened steel; at the same time, that the articles are so brittle as to break by falling on the ground. When, however, these goods are treated in the way above directed, they acquire a degree of softness which renders them penetrable by the file, and at the same time capable of bending. In this state, they are much less tenacious than steel, but still so much so, as to have been sold in the form of cutlery for steel.

The change which metals undergo by annealing, is not yet thoroughly understood. Most of the malleable metals are susceptible of two distinct forms, one called the crystalline form, which they assume by slow cooling; and the other, the fibrous, which is acquired by hammering or rolling. When this, however, is carried beyond a certain point, the metal becomes so hard, that it is not capable of being bent far without breaking. All the malleable metals in the ingot or in their cast state are brittle, and exhibit a crystalline fracture. By hammering or rolling, they become more tenacious, and break with difficulty, exhibiting what is called a fibrous fracture. At the same time, they become stiffer and more elastic. They lose the latter properties by annealing, but become more malleable. If the annealing, however, be long continued, the malleability diminishes, and they again have a crystalline fracture. Zinc by wire-drawing becomes very flexible, and possesses a degree of tenacity not inferior to that of copper. But, if it be kept in boiling water for a length of time, it will resume its original brittleness, and show a crystalline appearance when broken. This proves that the particles of metals can change their arrangement, without losing their solid form;—which is still more strongly confirmed by the fact, that brass wire loses its tenacity by exposure to the fumes of acids, and even by the presence of a damp atmosphere. This is not caused by the moisture, but by the action

of air upon the moistened surface. The manufacturers of common pins are obliged to keep their wire in a dry atmosphere, or immerged in water. If the wire be first moistened, and then exposed to the air, it will assume the brittle state much sooner. In this condition it breaks with a crystalline fracture, similar to that exhibited by an ingot. When a steel plate, such as a watch-spring, has been once tempered, the operation of simply rubbing it bright, will render it soft and elastic. The same change is brought about by slightly hammering it. It, however, resumes its elastic state, by being carefully heated till it becomes of a blue colour. If the heat be continued to redness, particularly in a close vessel, it becomes perfectly annealed. (T.)

# ANNUITIES.

Annuities have been treated of in the body of the work, but in such a manner as to render it necessary, that so useful a branch of knowledge should form the subject of an entirely new article in this place.

History. The doctrine of Compound Interest and Annuities-certain, is too simple ever to have occupied much of the attention of Mathematicians: inquiries into the values of interests dependent upon the continuance or the failure of human life, being more interesting and difficult, have occupied them more, but yet not so much as their importance would seem to demand; the discoveries, both in pure Mathematics and Physics, especially those of Newton, which distinguished the close of the seventeenth century, having provided them with ample employment of a more interesting kind, ever since the subjects of this article were submitted to calculation.

Fermat, Pascal, and Huygens, by laying the foundation of the doctrine of Probabilities about the middle of that century, first opened the way to the solution of problems of this kind. The earliest mathematical publication on Probabilities, the little tract of Huygens, *De ratiociniis in ludo aleæ*, appeared in 1658; and in 1671, his celebrated countryman, John De Witt, published a treatise on Life-annuities, in Dutch. (*Montucla, Hist. des Math.* Tom. III. p. 407.) This, however, appears to have been very little known, or read, and to have had no sensible influence on the subsequent progress of the science; the origin of which may be properly dated from the publication of Dr Halley's paper on the subject, in the *Philosophical Transactions* for the year 1693 (No. 196.) That celebrated Mathematician there first gave a table of mortality, which he had constructed from observations made at Breslaw, and showed how the probabilities of life and death, and the values of annuities and assurances on lives, might be determined by such tables; which, he informs us, had, till then, been only done by an imaginary valuation. Besides his algebraical reasonings, he illustrated the subject by the properties of parallelograms, and parallelopipedons: there are, perhaps, no other mathematical inquiries, in the prosecution of which, algebra is entitled to so decided a preference to the elementary geometry as in these, and this example of the application of geometry has not been followed by any of the succeeding writers.

In the year 1724, Mr De Moivre published the first edition of his tract, entitled, *Annuities on Lives*. In order to shorten the calculation of the values of such annuities, he assumed the annual decrements of life to be equal; that is, that out of a given number of persons living at any age, an equal number dies every year until they are all extinct; and, upon that hypothesis, he gave a general theorem, by which the values of annuities on single lives might be easily determined: this approximation, when the utmost limit of life was supposed to be 86 years, agreed very well with the true values between 30 and 70 years of age, as deduced from Dr Halley's table, and the method was of great use at the time; as no tables of the true values of annuities had then been calculated, except a very contracted one inserted by Dr Halley in the paper mentioned above. But, upon the whole, this hypothesis of De Moivre has probably contributed to retard the progress of the science, by turning the attention of Mathematicians from the investigation of the true law of mortality, and the best methods of constructing tables of the real values of annuities.

The same distinguished Analyst also endeavoured to approximate the values of joint lives; but it has since been found, that the formulæ he gave for that purpose are too incorrect for use. Mr Thomas Simpson published his *Doctrine of Annuities and Reversions* in the year 1742, in which the subject is treated in a manner much more general and perspicuous than it had been previously; his formulæ are adapted to any table of mortality, and, in the 7th corollary to his first problem, he gave the theorem demonstrated in the 149th number of this article, to which we owe all the best tables of the values of life-annuities that have since been published.

In the same work, he also gave a table of mortality deduced from the London observations, and four others calculated from it, of the values of annuities on lives, each at three rates of interest; the first for single lives, the three others for two and three equal joint lives, and for the longest of two or of three lives.

These were the first tables of the values of joint lives that had been calculated; for although Dr Halley had shown, half a century before, how such tables might be computed, and had taken considerable pains to facilitate the work; the necessary calculations, by the known methods, previous to the publication of Mr Simpson's Treatise, were so very labo-

History.

rious, that no one had had the courage to undertake them. And, unfortunately, the mortality, according to the London table, was so much above the common average, that the values of annuities in Mr Simpson's tables were much too small for general use.

In the year 1746, M. Deparcieux published his *Essai sur les probabilités de la durée de la vie humaine*, in which he gave several valuable tables of mortality deduced from the mortuary registers of different religious houses, and from the lists of the Nominees in the French Tontines; also a table of the values of annuities on single lives, at three rates of interest, calculated from his table of mortality for the tontine annuitants. These tables were a great acquisition to the science, as, before their publication, there were only two extant that gave tolerably exact representations of the true law of mortality;—Dr Halley's for Breslaw, and one constructed but a short time before by M. Kerseboom, principally from registers of Dutch annuitants. Those of M. Deparcieux for the Monks and Nuns, were the first ever constructed for the two sexes separately; and by them, the greater longevity of females was made evident.

The work commences with an algebraical theory of Annuities-certain; but the principal essay, *On the Probabilities of the Duration of Human Life*, is perfectly intelligible to those who have not studied Mathematics; it is written with great judgment and perspicuity, but contains very little more than the explanation of the construction of his tables, some of which relate to Tontines; and he did not avail himself to the extent he might have done, of the excellent tract of Thomas Simpson.

This work, however, appears to have been more read upon the Continent, and to have contributed more to the diffusion of this kind of information there, than all the other writings on the subject. The article *Rentes viageres* in the *Encyclopédie*, is acknowledged to have been taken entirely from it, as was also the article Vie, *durée de la ;* and these are proofs, among many others that might be produced, how little M. D'Alembert and the principal Mathematicians, his contemporaries, attended to the subject.

In the year 1752, Mr Simpson published, in his *Select Exercises*, a supplement to his Doctrine of Annuities; wherein he gave new tables of the values of annuities on two joint lives, and on the survivor of two lives, much more copious than those he had inserted in the principal work; but these also were calculated from his London table of mortality.

The celebrated Euler, in a paper inserted in the Memoirs of the Royal Academy of Sciences at Berlin for the year 1760, gave a formula by which the value of an annuity on a single life of any age, may be derived from that of an annuity on a life one year older; which formula was included in that given by Mr Simpson eighteen years before, for effecting the same purpose in the case of any number of joint lives; and by this compendious method, M. Euler calculated a table of the values of single lives from M. Kerseboom's table of mortality.

The first edition of Dr Price's *Observations on Reversionary Payments* was published in 1769; and its chief object was, to give information to persons desirous of forming themselves into societies for the purpose of making provision for themselves in old age, or for their widows. When tables of the values of single lives, and of two joint lives are given, the methods of determining the terms on which such provisions can be made with safety to all the parties concerned, are very simple, and were, at that time, well understood in theory, by the Mathematicians who had studied the subject; but, for want of the requisite tables, the algebraical formulæ had, till then, been of little practical utility.

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In the prosecution of this laudable design, Dr Price was obliged to have recourse to approximations. He informs us, that by following M. De Moivre too implicitly in his rules for determining the value of two joint lives, he was led into difficulties which convinced him that they were not only useless, but dangerous; he therefore calculated a table of these values upon M. De Moivre's hypothesis of the decrements of life being equal, and its utmost limit 86 years, from a correct formula given by Mr Simpson in his Doctrine of Annuities (Cor. 5. Prob. I.); by this, and a table of the values of single lives, calculated by Mr Dodson on M. De Moivre's hypothesis, he was enabled to give answers tolerably near the truth, to some of the most interesting questions of this kind, and to show that the plans of several of the societies then recently established, were quite inadequate; and instead of the benefits they promised, could only, in the end, produce disappointment and distress, unless they either dissolved or reformed themselves.

The work also contained instructive dissertations on the probabilities and expectations of life, and on the mean duration of marriage and of widowhood; besides accounts of some of the principal societies which had then been formed for the benefit of old age, and of widows; with observations on the method of forming tables of mortality for towns, and two new tables of that kind, constructed from registers kept at Norwich and Northampton. Mr Morgan's *Doctrine of Annuities and Assurances* was published in 1779, containing tables of the values of single lives, of two equal joint lives, and of two lives differing in age by 60 years. calculated from the Northampton table of mortality. And in the same year, M. De Saint-Cyran published his *Calcul des Rentes viageres sur une et sur plusieurs têtes*, wherein the valuation of annuities on lives is treated algebraically, but in a manner much inferior in all respects to that of Mr Simpson; and six tables are given of the values of annuities,—on single lives, on the survivor of two lives, and on the last survivor of three, calculated from M. Kerseboom's table of mortality. Although the values in the cases of two, and of three lives, were only determined by approximation, these tables were, just then, a valuable acquisition to the science; but their use was entirely superseded only four years after, by the publication of others much more valuable.

The fourth edition of Dr Price's *Observations on Reversionary Payments* appeared in 1783. One of the best effects of the preceding editions on the pro-

gress of the science, had been, to direct the public attention to these inquiries, by showing their important uses in the affairs of life; and to procure the requisite *data* for forming tables of mortality, that should illustrate the laws according to which human life wastes under different circumstances, by exciting the curiosity of intelligent men who had the necessary leisure and means of information. The ingenious author had, accordingly, been furnished with the necessary abstracts of mortuary registers which had been kept with these views, by Dr Haygarth at Chester, Dr Aikin at Warrington, and the Rev. Mr Gorsuch at Holy-Cross, near Shrewsbury, since the publication of the first edition; also by Mr Wargentin, with the mean numbers both of the living, and the annual deaths in all Sweden and Finland, for twenty-one successive years, in all of which the sexes were distinguished; and from these *data*, he constructed tables of mortality that threw great light on the subject. He also inserted in this edition, an improved table of mortality for Northampton; and, what had been so long wanted, a complete set of tables of the values of annuities on single lives, at six rates of interest, and on two joint lives at four, all calculated from the new Northampton table. The combinations of joint lives were sufficiently numerous to admit of all the values not included being easily interpolated. Besides these, he also gave tables of the values of annuities on single lives from the Swedish observations, both with and without distinction of the sexes, and on two joint lives without that distinction.

The values given in these tables are too low for the general average of lives, at all ages under 60; but in the treatise of Mr Baron Maseres on *the Principles of the Doctrine of Life-Annuities*, which was published in the same year (1783), others were given, calculated from the table of mortality which M. Deparcieux constructed from the lists of the Nominees in the French Tontines. The tables for single lives are calculated at twelve different rates of interest from 2 to 10 *per cent.*; but those for joint lives, only at $3\frac{1}{2}$ and $4\frac{1}{2}$ *per cent.*; and the combinations they include are only those of ages that are equal, or that differ by 5 or 10 years, and the multiples of 10.

There is reason to believe that the values in these tables, at all ages under 75 or 80 years, are nearer the truth, for the average of this country, than any others then extant; but certainly for the average of lives on which annuities and reversions depend. After that period of life, however, they are too small; and, in most cases, it is difficult to derive the values of joint lives from them with sufficient accuracy, on account of the contracted scale they have been calculated upon.

It was not Dr Price's object to deliver the elements of the science systematically; but he treated most parts of it with great judgment, enriched it with a vast collection of valuable facts and observations, and corrected several errors into which some of the most eminent writers upon it had fallen. The mathematical demonstrations (which are given in the notes) are much inferior to the rest of the work.

The values of reversionary sums and annuities, which depend upon some of the lives involved failing according to assigned orders of precedency, had been approximated by Mr Simpson in his *Select Exercises*, and by Mr Morgan in his *Doctrine of Annuities;* but the latter gentleman first gave accurate solutions of problems of this kind, in the *Philosophical Transactions* for the years 1788, 1789, 1791, 1794, and 1800.

Except by the solution of these problems, the science had not been materially advanced, during a period of more than thirty years that had elapsed since the appearance of the fourth edition of Dr Price's work, when Mr Milne published his *Treatise on the Valuation of Annuities and Assurances, on Lives and Survivorships*, in the beginning of last year (1815).

The work consists of two volumes; the first is mathematical, the second entirely popular, except the notes, and a few of the tables. The algebraical part of this article is merely a short abstract of the first volume, and may serve as a specimen of the manner in which the subject has been treated there; but the construction of tables of mortality, which forms the subject of the third chapter, has not been noticed here; neither is the valuation of reversionary sums or annuities depending upon assigned orders of survivorship, treated in the present article; and these are parts of the work, which will not be found the least interesting to mathematicians.

The second volume contains upwards of fifty new tables, with a few others that had been published before, but have been reprinted either on account of their value, or scarcity, or both. Four of the new ones are tables of mortality constructed by the author, from registers kept at Carlisle and Montpellier, and in all Sweden and Finland, since the period of the observations Dr Price made use of; the sexes are distinguished in the tables for Sweden and Montpellier, but not in that for Carlisle. This last is the only table, besides those for Sweden and Finland, that has been formed from the necessary *data*,—enumerations of the living, as well as registers of the deaths in every interval of age.

Twenty-one of these tables, being the seventeenth to the thirty-seventh inclusive, in the collection at the end of the work, render it easy to apply the algebraical formulæ to practical purposes, and numerous examples of such applications are given. They have all been calculated from the Carlisle table of mortality; those of the values of life-annuities on the same extensive scale, with those which Dr Price derived from the Northampton table. It is the author's opinion that the values of interests dependent upon the continuance or the failure of life, may be derived from them more correctly than from any others extant, and he has taken considerable pains to assist his readers in judging of this for themselves.

Besides the tables, the principal contents of the second volume, are explanations of their construction and uses; many of them relate to the progress of population,—the comparative mortality of different diseases—of different seasons,—and of the two sexes at every age—the proportion of the sexes at birth—and that of the born alive to the still-born of each sex.

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It will be found that the author has been furnished with facts and observations of great value, and that he has endeavoured to present the information they afford, in the forms best calculated for the further prosecution of these inquiries.

Plan of this Article.

In treating of annuities, we think that it may be useful in a work of this kind, to address ourselves as well to those readers who have not, as to those who have, an acquaintance with *Algebra*; and we shall, accordingly, divide what follows into two Parts, corresponding to these two views of the subject.

## PART I.

We shall, in this Part, demonstrate all that is most useful and important in the doctrine of Annuities and Assurances on lives, without using Algebra, or introducing the idea of probability; but the reader is, of course, supposed to understand common Arithmetic. In the first 30 numbers of this Part, *Compound Interest* and *Annuities-certain* are treated of; from the 31st to the 76th, the doctrine of *Annuities on Lives* is delivered; and that of *Assurances* on Lives, from thence to the 108th, where the popular view terminates.

What is demonstrated in this Part, will be sufficient to give the reader clear and scientific views of the subjects treated; and, with the assistance of the necessary tables, will enable him to solve the more common and simple problems respecting the values of Annuities and Assurances. He will also understand clearly the general principles on which problems of greater difficulty are resolved; but these he cannot undertake with propriety, when the object is, to make a fair valuation of any claims or interests, with a view to an equitable distribution of property, unless he has studied the subject carefully, with the assistance of Algebra; for intricate problems of this kind can hardly be solved without it; and those who are not much exercised in such inquiries, often think they have arrived at a complete solution, when they have overlooked some circumstance or event, or some possible combination of events or circumstances, which materially affect the value sought. Eminent Mathematicians have, in this way, fallen into considerable errors, and it can hardly be doubted, that those who are not mathematicians, must (*cæteris paribus*) be more liable to them.

### I. ON ANNUITIES-CERTAIN.

No. 1. When the rate is 5 *per cent.*, L.1 improved at simple interest during one year, will amount to L. 1·05; which, improved in the same manner during the second year, will be augmented in the same ratio of 1 to 1·05; the amount then, will therefore be $1{\cdot}05 \times 1{\cdot}05$, or $(1{\cdot}05)^2 = 1{\cdot}1025$.

In the same manner it appears, that this last amount, improved at interest during the third year, will be increased to $(1{\cdot}05)^3 = 1{\cdot}157625$; at the end of the fourth year, it will be $(1{\cdot}05)^4$; at the end of the fifth $(1{\cdot}05)^5$, and so on; the amount at the end of any number of years being always determined, by raising the number which expresses the amount at the end of the first year, to the power of which the exponent is the number of years. So that when the rate of interest is 5 *per cent.*, L.1 improved at compound interest, will, in seven years, amount to $(1{\cdot}05)^7$, and in 21 years, to $(1{\cdot}05)^{21}$.

But if the rate of interest were only 3 *per cent.*, these amounts would only be $(1{\cdot}03)^7$, and $(1{\cdot}03)^{21}$ respectively.

2. The present value of L.1 to be received certainly at the end of any assigned term, is such a less sum, as, being improved at compound interest during the term, will just amount to one pound. It must therefore be less than L.1, in the same ratio as L.1 is less than its amount in that time; but in three years, at 5 *per cent.*, L.1 will amount to L. $(1{\cdot}05)^3$ (1). And $(1{\cdot}05)^3 : 1 :: 1 : \frac{1}{(1.05)^3}$, so that $\frac{1}{(1{\cdot}05)^3} = \frac{1}{1{\cdot}157625} = 0{\cdot}863838$ is the present value of L.1 to be received at the expiration of three years.

In the same manner it appears that, at 4 *per cent.* interest, the present value of L.1 to be received at the end of a year, is $\frac{1}{1{\cdot}04} = 0{\cdot}961538$; and if it were not to be received until the expiration of 21 years, its present value would be $\frac{1}{(1{\cdot}04)^{21}} = (0{\cdot}961538)^{21} = 0{\cdot}438834$.

Hence it appears, that if unity be divided by the amount of L.1, improved at compound interest during any number of years, the quotient will be the present value of L.1 to be received at the expiration of the term: which may also be obtained by raising the number which expresses the present value of L.1 receivable at the expiration of a year, to the power of which the exponent is the number of years in the term.

3. When a certain sum of money is receivable annually, it is called an Annuity, and its *quantum* is expressed by saying it is an annuity of so much; thus, according as the annual payment is L.1, L.10, or L.100; it is called an annuity of L.1, of L.10, or of L.100.

4. When the annual payment does not depend upon any contingent event, but is to be made certainly, either in perpetuity or during an assigned term, it is called an *Annuity-certain*.

5. In calculating the value of an annuity, the first payment is always considered to be made at the end of the first year from the time of the valuation, unless the contrary be expressly stated.

6. The whole number, and part or parts of one annual payment of an annuity, which all the future payments are worth in present money, is called *the number of years purchase* the annuity is worth; and,

being the sum of the present values of all the future payments, is also the sum which, being put out and improved at compound interest, will just suffice for the payment of the annuity (2).

7. Hence it follows, that when the annuity is L. 1, the number of years purchase and parts of a year, is the same as the number of pounds and parts of a pound in its present value.

And throughout this article, whenever the *quantum* of an annuity is not mentioned, it is to be understood to be L. 1.

8. The sum of which the simple interest for one year is L. 1, is evidently that which, being put out at interest, will just suffice for the payment of L. 1 at the end of every year, without any augmentation or diminution of the principal; and, being equivalent to the title to L. 1 *per annum* for ever, is called the *value of the perpetuity*, or the number of years purchase the perpetuity is worth.

But, while the rate remains the same, the annual interests produced by any two sums, are to each other as the principals which produce them; therefore, since $5 : 1 :: 100 : \frac{100}{5} = 20$, when the rate of interest is 5 *per cent.*, the value of the perpetuity is 20 years purchase. In the same manner it appears, that according as the rate may be 3 or 6 *per cent.* the value of the perpetuity will be $\frac{100}{3} = 33\frac{1}{3}$, or $\frac{100}{6} = 16\frac{2}{3}$ years purchase; and may be found in every case, by dividing any sum by its interest for a year.

9. All the most common and useful questions in the doctrines of compound interest and annuities-certain, may be easily resolved by means of the first four tables at the end of this article. Their construction may be explained by the following specimen, rate of interest 5 *per cent.*

| Construction of | | | | | |
|---|---|---|---|---|---|
| | Table IV. | Table III. | Table I. | Table II. | |
| | Amount of L. 1 *per annum*. | Amount of L. 1. | Present value of L. 1 to be received at | Present value of L. 1 *per annum*, to be received until | |
| Term. | improved at Interest until | | | | Term. |
| | the Expiration of the Term. | | | | |
| 1 Yr. | 1·000000 | 1·050000 | ·952381 | 0·952381 | 1 Yr. |
| 2 Yrs. | 2·050000 | 1·102500 | ·907029 | 1·859410 | 2 Yrs. |
| 3 | 3·152500 | 1·157625 | ·863838 | 2·723248 | 3 |
| 4 | 4·310125 | 1·215506 | ·822702 | 3·545950 | 4 |
| 5 | 5·525631 | 1·276282 | ·783526 | 4·329476 | 5 |
| 6 | 6·801913 | 1·340096 | ·746215 | 5·075691 | 6 |
| 7 | 8·142009 | 1·407100 | ·710681 | 5·786372 | 7 |

10. The calculation must begin with Table III., the first number in which should evidently be 1·05, the amount of L. 1 improved at interest during one year; which, being multiplied by 1·05, the product is 1·025, the second number; this second number being multiplied by 1·05, the product is 1·157625, the amount at the end of three years. And so the calculation proceeds throughout the whole of the column; each number after the first, being the product of the multiplication of the preceding number, by the amount of L. 1 in a year (1).

11. The number against any year in Table I. is found by dividing unity by the number against the same year in Table III. (2); thus, the number against the term of six years in Table I. is $\frac{1}{1·340096} = ·746215$. All the numbers in that table after the first, may also be found, by multiplying that first number continually into itself (2).

12. The number against any year in Table II. being the sum of the numbers against that and all the preceding years in Table I.; is found by adding the number against that year in Table I. to the number against the preceding year in Table II.; thus, the number against 4 years in Table II., being

the sum of 0·822702
and 2·723248

is 3·545950.

13. If each payment of an annuity of L. 1 be put out as it becomes due, and improved at compound interest during the remainder of the term, it is evident that at the expiration of the term, the payment then due will be but L. 1, having received no improvement at interest. That received one year before will be augmented to the amount of L. 1 in a-year; that received two years before will be augmented to the amount of L. 1 in two years; that received three years before to the amount of L. 1 in three years, and so on until the first payment, which will be augmented to the amount of L. 1 in a term one year less than that of the annuity.

Hence, it is manifest, that the number against any year in Table IV. will be unity added to the sum of all those against the preceding years in Table III.

And, therefore, that the number against any year in Table IV. is the sum of those in Tables III. and IV. against the next preceding year.

Thus, the number against seven years in Table IV., being

the sum of 1·340096
and 6·801913

is 8·142009.

14. The method of construction is obviously the same at any other rate of interest.

15. All the amounts and values which are the objects of this inquiry, evidently depend upon the improvement of money at compound interest; it is, therefore, that the first, second, and fourth tables, all depend upon the third.

But every pound, and every part of a pound, when put out at interest, is improved in the same manner as any single pound considered separately. Whence, it is obvious, that while the term and the rate of interest remain the same, both the amount and the present value, either of any sum, or of any annuity, will be the same multiple, and part or parts of the amount or the present value found against the same term, and under the same rate of interest in these tables, as the sum or the annuity proposed is of L. 1.

So that to find the amount or the present value of

any sum or annuity for a given term and rate of interest, we have only to multiply the corresponding tabular value by the sum or the annuity proposed; the product will be the amount or the value sought, according as the case may be.

16. *Example* 1. To what sum will L. 100 amount, when improved at compound interest during 20 years? the rate of interest being 4 *per cent. per annum.*

By Table III., it appears, that L. 1 so improved, would, at the expiration of the term, amount to L. 2·191123, therefore L. 100 would amount to 100 times as much, that is, to L. 219·1123, or L. 219, 2s. 3d.

17. *Ex.* 2. What is the present value of L. 400, which is not to be received until the expiration of 14 years, when the rate of interest is 5 *per cent.?*

The present value of L. 1 to be received then, will be found by Table I. to be L. 0·505068 : L. 400 to be received at the same time, will therefore be worth, in present money, 400 times as much, or L. 202·0272, that is, L. 202, 0s. $6\frac{1}{2}$d.

18. *Ex.* 3. Required the present value of an annuity of L. 50 for 21 years, when the rate of interest is 5 *per cent.*

Table II. shows the value of an annuity of L. 1 for the same term to be L. 12·8212 ; the required value must therefore be 50 times as much, or L. 641·06, that is, L. 641, 1s. $2\frac{1}{2}$d.

19. *Ex.* 4. What will an annuity of L. 10, 10s. or L. 10·5, for thirty years, amount to, when each payment is put out as it becomes due, and improved at compound interest until the end of the term? The rate of interest being 4 *per cent.*

The amount of an annuity of L. 1 so improved, would be L. 56·084938, as appears by Table IV., the amount required will therefore be 10·5 times this, or L. 588·89185, that is, L. 588, 17s. 10d.

20. When the interval between the time of the purchase of an annuity and the first payment thereof, exceeds that which is interposed between each two immediately successive payments; such annuity is said to be *deferred* for a time equal to that excess, and to be *entered upon* at the expiration of that time.

21. If two persons, *A* and *B*, purchase an annuity between them, which *A* is to enter upon immediately, and to enjoy during a certain part of the term, and B, or his heirs, or assigns, for the remainder of it ; the present value of *B's* interest will evidently be, the excess of the value of the annuity for the whole of the term from this time, above the value of the interest of *A*.

So that when the entrance on an annuity is deferred for a certain term, its present value will be the excess of the value of the annuity for the term of delay and continuance together, above the value of an equal annuity for the term of delay only.

22. *Example* 1. Required the value of a perpetual annuity of L. 120, which is not to be entered upon until the expiration of 14 years from this time, reckoning interest at 3 *per cent.*

The perpetuity, with immediate possession, would be worth $33\frac{1}{3}$ years' purchase (8) ; and an annuity for the term of delay is worth 11·2961 (Table II.)

| | |
|---|---|
| From | 33·3333 |
| subtract | 11·2961, and multiply |
| the remainder | 22·0372 |
| by - | 120 |
| the product | 2644·464 = L. 2644, 9s. $3\frac{1}{4}$d. |

is the required value.

23. *Ex.* 2. Allowing interest at 5 *per cent.* what sum should be paid down now for the renewal of 14 years lapsed, in a lease for 21 years of an estate producing L. 300 *per annum*, clear of all deductions?

This is the price of an annuity for 14 years, to be entered upon 7 years hence ; the term of delay, therefore, is 7 years, and that of the delay and continuance together 21 years.

By Table II. it appears, that the present value of an annuity

| | | |
|---|---|---|
| for 21 years, is - - | 12·8212 | years' purchase. |
| for 7 years, - - | 5·7864 | |
| Value of the deferred annuity, | 7·0348 | |
| Multiply by - - | 300 | |
| The product - | L. 2110·44, or L. 2110, | |

8s. $9\frac{1}{2}$d. is the price required.

24. Hitherto we have proceeded upon the supposition of the annuity being payable, and the interest convertible into principal, which shall reproduce interest, only once a-year.

But annuities are generally payable half-yearly, and sometimes quarterly ; and the same circumstances that render it desirable for an annuitant to receive his annual sum in equal half-yearly or quarterly portions, also give occasion to the interest of money being paid in the same manner.

But whatever has been advanced above, concerning the present value or the amount of an annuity, when both that and the interest of money were only payable once a-year, will evidently be true when applied to half the annuity, and half the interest paid twice as often, on the supposition of half-yearly payments ; or to a quarter of the annuity, and a quarter of the interest, paid four times as often, when the payments are made quarterly.

25. Half-yearly payments are, however, by far the most common, and these four tables will also enable us to answer the most useful questions concerning them.

For we have only to extract the present value, or the amount, from the table, against twice the number of years in the term, at half the annual rate of interest, and, in the case of an annuity, to multiply the number so extracted, by half the annuity proposed.

26. *Ex.* 1. To what sum will L. 100 amount in 20 years, when the interest at the rate of 4 *per cent. per annum*, is convertible into principal half-yearly?

This being the amount in 40 half years at 2 *per cent.* interest for every half year, will be the same as the amount in 40 years at 2 *per cent. per annum*, which, by Table III. will be found to be 220·804, or L. 220, 16s. 1d. ; and is only L. 1, 13s. 10d. more than it would amount to if the interest were not convertible more than once a-year (16).

27. *Ex.* 2. What is the present value of an annuity of L. 50 for 21 years, receivable in equal half-yearly payments, when money yields an interest of $2\frac{1}{2}$ *per cent.* every half year?

By Table II. it appears, that an annuity of L. 1 for 42 years, when the interest of money is $2\frac{1}{2}$ *per cent. per annum*, will be worth L. 25·8206 (25); 25 times this sum, or L. 645, 10s. $3\frac{1}{2}$d. is therefore, the required value, and exceeds the value when the interest and the annuity are only payable once a-year by L. 4, 9s. 1d. (18).

28. The excess of an annuity-certain above the interest of the purchase-money, is the sum which, being put out at the time of each payment becoming due, and improved at compound interest until the expiration of the term, will just amount to the purchase-money originally paid.

But, while everything else remains the same, the longer the term of the annuity is, the less must its excess above the interest of the purchase-money be, because a less annuity will suffice for raising the same sum within the term. Therefore, the proportion of that excess to the annual interest of the purchase-money, continually diminishes as the term is extended; and when the annuity is a perpetuity, there is no such excess (8).

29. The reason why the value of an annuity is increased by that and the interest being both payable more than once in the year, is, that the grantor loses, and the purchaser gains, the interest produced by that part of each payment, which is in excess above the interest then due upon the purchase-money, from the time of such payment being made, until the expiration of the year.

Hence it is obvious, that the less this excess is, that is, the longer the term of the annuity is (28), the less must the increase of value be.

And when the annuity is a perpetuity, its value will be the same, whether it and the interest of money be both payable several times in the year, or once only.

30. When the annuity is not payable at the same intervals at which the interest is convertible into principal, its value will depend upon the frequencies both of payment and conversion; but its investigation without algebra, would be too long, and of too little use, to be worth prosecuting here.

## II. OF ANNUITIES ON LIVES.

31. When the payment of an annuity depends upon the existence of some life or lives, it is called a *Life-annuity*.

32. The values of such annuities are calculated by means of tables of mortality, which show, out of a considerable number of individuals born, how many upon an average have lived to complete each year of their age; and, consequently, what proportion of those who attained to any one age, have survived any greater age.

The fifth Table at the end of this article is one of that kind, which has been taken from Mr Milne's *Treatise on Annuities*, and was constructed from accurate observations made at Carlisle by Dr Heysham, during a period of 9 years, ending with 1787.

33. By this table it appears, that during the period in which these observations were made; out of 10,000 children born, 3203 died under 5 years of age, and the remaining 6797 completed their fifth year. Also, that out of 6797 children who attained to 5 years of age, 6460 survived their 10th year.

But the mortality under 10 years of age, has been greatly reduced since then, by the practice of vaccination.

This table also shows, that of 6460 individuals who attained to 10 years of age, 6047 survived 21. And that of 5075 who attained to 40, only 3643 survived their 60th year.

34. There is good reason to believe (as has been shown in another place), that the general law of mortality, that is, the average proportion of persons attaining to any one age, who survive any greater age, remains much the same now among the entire mass of the people throughout England, as it was found to be at Carlisle during the period of these observations; except among children under 10 years of age, as was noticed above (33).

If this be so, it will follow, that of 6460 children now 10 years of age, just 6047 will attain to 21; or rather, that if any great number be taken in several instances, this $\left(\frac{6047}{6460}\right)$ will be the average proportion of them that will survive the period.

And if 6460 children were to be taken indiscriminately from the general mass of the population at 10 years of age, and an office or company were to engage to pay L. 1, eleven years hence, for each of them that might then be living; this engagement would be equivalent to that which should bind them to pay L. 6047 certainly, at the expiration of the term. Therefore, the office, in order that it might neither gain nor lose by the engagement, should, upon entering into it, be paid for the whole, the present value of L. 6047, to be received at the expiration of 11 years; and for each life, the $\frac{1}{6460}$th part of it; that is, the $\frac{6047}{6460}$th part of the present value of L. 1 to be received then.

But when the rate of interest is 5 *per cent.* the present value of L. 1, to be received at the expiration of 11 years, is L. 0·584679; therefore, at that rate of interest, there should be paid for each life $\frac{6047 \times 0{\cdot}584679}{6460} =$ L. 0·5473.

And the present value of L. 100, to be received upon a life now 10 years of age attaining to 21, will be L. 54·73, or L. 54, 14s. 7d.

In the same manner it will be found, that reckoning interest at 4 *per cent.* the value would be L. 60, 16s. 1d.

35. This is the method of calculating the present values of endowments for children of given ages; and the values of annuities on lives may be computed in the same manner.

For, from the above reasoning it is manifest, that if the present value of L. 1, to be received certainly at the expiration of a given term, be multiplied by the number in the table of mortality against the

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age, greater than that of any proposed life by the number of years in the term, and the product be divided by the number in the same table, against the present age of that life; the quotient will be the present value of L. 1, to be received at the expiration of the term, provided that the life survive it.

And if, in this manner, the value be determined of L. 1, to be received upon any proposed life, surviving each of the years in its greatest possible continuance, according to the table of mortality adapted to it; that is, according to the Carlisle table, upon its surviving every age greater than its present, to that of 104 years inclusive; then, the sum of all these values will evidently be the present value of an annuity on the proposed life.

36. If 5642 lives at 30 years of age be proposed, and 5075 at the age of 40; since each of the 5642 younger lives may be combined with every one of the 5075 that are 10 years older, the number of different pairs, or different combinations of two lives differing in age by 10 years, that may be formed out of the proposed lives, is 5642 times 5075.

But at the expiration of 15 years, the survivors of the lives now 30 and 40 years of age, being then of the respective ages of 45 and 55, will be reduced to the numbers of 4727 and 4073 respectively; and the number of pairs, or combinations of two, differing in age by 10 years, that can be formed out of them, will be reduced from $5642 \times 5075$ to $4727 \times 4073$.

So that L. 1 to be paid at the expiration of 15 years for each of these $5642 \times 5075$ pairs or combinations of two, now existing, which may survive the term, will be of the same value in present money, as 4727 times L. 4073, to be received certainly at the same time.

Now let A be any one of these lives of 30 years of age, and B any one of those aged 40; and from what has been advanced it will be evident, that the present value of L. 1 to be received upon the two lives in this particular combination jointly surviving the term, will be the same as that of the sum L. $\frac{4727 \times 4073}{5642 \times 5075}$ to be then received certainly.

But, when the rate of interest is 5 *per cent.* L. 1 to be received certainly at the expiration of 15 years, is equivalent to L. 0·481017 in present money (Table I).

Therefore, at that rate of interest, and according to the Carlisle table of mortality; the present value of L. 1 to be received upon A and B now aged 30 and 40 years respectively, jointly surviving the term of 15 years, will be $\frac{4727 \times 4073 \times \text{L. } 0{\cdot}481017.}{5642 \times 5075.}$

37. Hence it is sufficiently evident, how the present value of L. 1 to be received upon the same two lives jointly surviving any other year may be found. And if that value for each year from this time until the eldest life attain to the limit of the table of mortality be calculated, the sum of all these will be the present value of an annuity of L. 1 dependent upon their joint continuance.

In this manner, it is obvious that the value of an annuity on the joint continuance of any other two lives might be determined.

38. If, besides the 5642 lives at 30 years of age, and the 5075 at 40 (mentioned in No. 36), there be also proposed 3643 at 60 years of age; each of these 3643 at 60, may be combined with every one of the $5642 \times 5075$ different combinations of a life of 30, with one of 40 years of age; and, therefore, out of these three classes of lives $5642 \times 5075 \times 3643$ different combinations may be formed; each containing a life of 30 years of age, another of 40, and a third of 60.

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But at the expiration of 15 years, the numbers of lives in these three classes will, according to the table of mortality, be reduced to 4727, 4073, and 1675 respectively; the respective ages of the survivors in the several classes being then 45, 55, and 75 years; and the number of different combinations of three lives (each of a different class from either of the other two), that can be formed out of them, will be reduced to $4727 \times 4073 \times 1675$.

Hence, by reasoning as in No. 36, it will be found, that if A, B, and C be three such lives, now aged 30, 40, and 60 years, the present value of L. 1 to be received upon these three jointly surviving the term of 15 years from this time, will be $\frac{4727 \times 4073 \times 1675}{5642 \times 5075 \times 3643} \times \text{L. } 0{\cdot}481017$: interest being reckoned at 5 *per cent.*

Thus it is shown, how the present value of an annuity dependent upon the joint continuance of these three lives might be calculated, that being the sum of the present values thus determined, of the rents for all the years which, according to the table of mortality, the eldest life can survive.

39. But it is easy to see, that the same method of reasoning may be used in the case of four, five, or six lives, and so on without limit. Whence, this inference is obvious.

The present value of L. 1, to be received at the expiration of a given term, provided that any given number of lives all survive it, may be found by multiplying the present value of L. 1 to be received certainly at the end of the term, by the continual product of the numbers in the table of mortality against the ages greater respectively by the number of years in the term, than the ages of the lives proposed; and dividing the last result of these operations, by the continual product of the numbers in the table of mortality against the present ages of the proposed lives.

And by a series of similar operations, the present value of an annuity on the joint continuance of all these lives might be determined.

But it should be observed, that, in calculating the value of a life-annuity in this way, the denominator of the fractions expressing the values of the several years rents, that is, the divisor used in each of the operations, remains always the same; the division should, therefore, be left till the sum of the numerators is determined, and one operation of that kind will suffice.

40. Enough has been said to show that these methods of constructing tables of the values of annuities on lives are practicable, though excessively laborious, and, in fact, all the early tables of this kind were constructed in that manner. We proceed now

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to show how such tables may be calculated with much greater facility.

41. By the method of No. 34, it will be found that, reckoning interest at 5 *per cent.*, the present value of L. 1 to be received at the expiration of a year, provided that a life, now 89 years of age, survived till then, is $\frac{142 \times 0{\cdot}95238}{181}$. But the age of that life will then be 90 years, and the proprietor of an annuity of L. 1 now depending upon it, will, in that event, receive his annual payment of L. 1 then due; therefore, if the value then of all the subsequent payments, that is, the value of an annuity on a life of 90 be 2·339 years' purchase, the present value of what the title to this annuity may produce to the proprietor, at the end of the year, will be the same as that of L. 3·339, to be received then, if the life be still subsisting, or $\frac{142 \times 0{\cdot}952381}{181} \times$ L. $3{\cdot}339 =$ L. 2·495; which, therefore, will be the present value of an annuity of L. 1 on a life of 89 years of age. That is to say, an annuity on that life will now be worth 2·495 years' purchase (7).

42. In the same manner it appears generally, that, if unity be added to the number of years' purchase that an annuity on any life is worth, and the sum be multiplied by the present value of L. 1, to be received at the end of a year, provided that a life one year younger survive till then, the product will be the number of years' purchase an annuity on that younger life is worth in present money.

43. But according to the table of mortality, an annuity on the eldest life in it is worth nothing; therefore, the present value of L. 1 to be received at the end of a year, provided that the eldest life but one in the table survive till then, is the total present value of an annuity of L. 1 on that life. Which, being obtained, the value of an annuity on a life one year younger than it may be found by the preceding number; and so on for every younger life successively.

Exemplification.

Rate of Interest 5 *per cent.*

| Age of Life. | Value of an Annuity on that Life, increased by Unity. | Which, being multiplied by 0·952381, and the Product by | Produces the value of an Annuity on the next younger Life | Its Age being |
|---|---|---|---|---|
| 104 | 1·000 | $\frac{1}{5}$ | 0·317 | 103 |
| 103 | 1·317 | $\frac{3}{5}$ | 0·753 | 102 |
| 102 | 1·753 | $\frac{5}{7}$ | 1·192 | 101 |
| 101 | 2·192 | $\frac{7}{9}$ | 1·624 | 100 |
| 100 | 2·624 | $\frac{9}{11}$ | 2·045 | 99 |
| 99 | 3·045 | $\frac{11}{14}$ | 2·278 | 98 |
| 98 | 3·278 | $\frac{14}{18}$ | 2·428 | 97 |
| 97 | 3·428 | $\frac{18}{23}$ | 2·555 | 96 |
| 96 | 3·555 | $\frac{23}{30}$ | 2·596 | 95 |
| 95 | 3·596 | $\frac{30}{40}$ | 2·569 | 94 |

44. Proceeding as in No. 36, it will be found, that at 5 *per cent.* interest, and according to the Carlisle table of mortality, the present value of L. 1 to be received at the expiration of a year, provided that a person now 89 years of age, and another now 99, be then living, is $\frac{142 \times 9 \times \text{L. } 0{\cdot}952381}{181 \times 11}$: therefore, if the present value of an annuity of L. 1 on the joint continuance of two lives, now aged 90 and 100 years respectively, be L. 0·950; by reasoning as in No. 41, it will be found that the present value of an annuity on the joint continuance of two lives, of the respective ages of 89 and 99 years, will be worth $\frac{142 \times 9 \times 0{\cdot}952381}{181 \times 11} \times 1{\cdot}950 = 1{\cdot}192$ years' purchase.

45. In this manner, commencing with the two oldest lives in the table that differ in age by ten years, and proceeding according to No. 43, the values of annuities on all the other combinations of two lives of the same difference of age, may be determined.

The method is exemplified in the following specimen:

| Ages of two Lives. | Value of an Annuity on their joint continuance, increased by Unity. | Which, being multiplied by 0·952381, and the Product by | Produces the value of an Annuity on the two joint Lives one year younger respectively, | their Ages being |
|---|---|---|---|---|
| 94 & 104 | 1·000 | $\frac{1 \times 40}{3 \times 54}$ | 0·235 | 93 & 103 |
| 93 & 103 | 1·235 | $\frac{3 \times 54}{5 \times 75}$ | 0·508 | 92 & 102 |
| 92 & 102 | 1·508 | $\frac{5 \times 75}{7 \times 105}$ | 0·733 | 91 & 101 |
| 91 & 101 | 1·733 | $\frac{7 \times 105}{9 \times 142}$ | 0·950 | 90 & 100 |
| 90 & 100 | 1·950 | $\frac{9 \times 142}{11 \times 181}$ | 1·192 | 89 & 99 |
| 89 & 99 | 2·192 | $\frac{11 \times 181}{14 \times 232}$ | 1·280 | 88 & 98 |

46. Hence, and by what has been advanced in the 39th number of this article, it is sufficiently evident, how a table may be computed of the values of annuities on the joint continuance of the lives in every combination of three, or any greater number; the differences between the ages of the lives in each combination remaining always the same in the same series of operations, while the calculation proceeds back from the combination in which the oldest life is the oldest in the table, to that in which the youngest is a child just born.

47. But, when there are more than two lives in each combination, the calculations are so very laborious, on account, principally, of the great number

of combinations, that no tables of that kind have yet been published, except three or four for three lives.

And, in the books that contain tables of the values of two joint lives, methods are given of approximating towards the values of such combinations of two and of three lives, as have not yet been calculated.

Therefore, assuming the values of annuities on single lives, and on the joint continuance of two or of three lives, to be given; we have next to show how the most useful problems respecting the values of any interests that depend upon the continuance or the failure of life, may be resolved by them.

48. *Proposition* 1. The value of an annuity on the survivor of two lives, *A* and *B*, is equal to the excess of the sum of the valnes of annuities on the two single lives, above the value of an annuity on their joint continuance.

49. *Demonstration.* If annuities on each of the two lives were granted to *P*, during their joint continuance, he would have two annuities; but if *P* were only to receive these upon condition that, during the joint lives of *A* and *B*, he should pay one annuity to *Q*; then, there would only remain one to be enjoyed by him, or his heirs or assigns, until the lives both of *A* and *B* were extinct; whence the truth of the proposition is manifest.

50. *Prop.* 2. The value of an annuity on the joint continuance of the two last survivors out of three lives, *A*, *B*, and *C*, is equal to the excess of the sum of the values of annuities on the three combinations of two lives (*A* with *B*, *A* with *C*, and *B* with *C*) that can be formed out of them, above twice the value of an annuity on the joint continuance of all the three lives.

51. *Demons.* If one annuity were granted to *P* on the joint continuance of the two lives *A* and *B*, another on the joint continuance of *A* and *C*, and a third, on the joint continuance of *B* and *C*; during the joint continuance of all the lives he would have three annuities.

But if he were only to receive these upon condition that he should pay two annuities to *Q*, during the joint continuance of all the three lives; then, there would only remain to himself one annuity during the joint existence of the last two survivors out of the three lives. And the truth of the proposition is manifest.

52. *Prop.* 3. The value of an annuity on the last survivor of three lives, *A*, *B*, and *C*, is equal to the excess of the sum of the values of annuities on each of the three single lives, together with the value of an annuity on the joint continuance of all the three, above the sum of the values of three other annuities; the first dependent upon the joint continuance of *A* and *B*, the second, on that of *A* and *C*, and the third, on *B* and *C*.

53. *Demons.* If annuities on each of the three single lives were granted to *R*; during the joint continuance of all the three, he would have three annuities, and from the time of the extinction of the first life that failed, till the extinction of the second, he would have two.

So that he would have two annuities during the joint existence of the two last survivors out of the three lives; and besides these, a third annuity during the joint continuance of all the three.

Therefore, if out of these, *R* were to pay one annuity to *P* during the joint continuance of the last two survivors out of the three lives, and another to *Q* during the joint continuance of all the three; he would only have left one annuity, which would be receivable during the life of the last survivor of the three.

But in the demonstration of the last proposition (51) it was shown, that the value of what he paid to *P*, would fall short of the sum of the values of annuities dependent respectively on the joint continuance of *A* and *B*, of *A* and *C*, and of *B* and *C*, by two annuities on the joint continuance of all the three lives. Whence it is evident, that the value of the annuities he paid both to *P* and *Q*, would fall short of the sum of these three values of joint lives, only by the value of one annuity on the joint continuance of all the three lives.

Wherefore, if from the sum of the values of all the three single lives, the sum of the values of the three combinations of two that can be formed out of them were taken; there would remain less than the value of an annuity on the last survivor, by that of an annuity on the joint continuance of the three lives.

But if, to the sum of the values of the three single lives *A*, *B*, and *C*, there be added that of an annuity on the joint continuance of the three, and from the sum of these four values, the sum of the values of the three combinations, *A* with *B*, *A* with *C*, and *B* with *C* be subtracted; then, the remainder will be the value of an annuity on the last survivor of the three lives. Which was to be demonstrated.

54. *Prop.* 4. *Problem.* The law of mortality and the values of single lives at all ages being given; to determine the present value of an annuity on any proposed life, deferred for any assigned term.

55. *Solution.* Find the present value of an annuity on a life older than the proposed, by the number of years during which the other annuity is deferred; multiply this by the present value of L. 1 to be received upon the proposed life surviving the term, and the product will be the value sought.

56. *Demons.* Upon the proposed life surviving the term, the annuity dependent upon it will be worth the same sum, that an annuity on a life so much older is now worth; therefore, it is evident, that the deferred annuity is of the same present value as that sum to be received at the expiration of the term, provided the life survive it.

57. *Corollary.* In the same manner it appears, that the present value of an annuity on the joint continuance of any number of lives, deferred for a given term, may be found by multiplying the present value of an annuity on the joint continuance of the same number of lives, older respectively than the proposed, by the number of years in the term; by the present value of L. 1 to be received, upon the proposed lives all surviving it.

58. A *Temporary Annuity* on any single life, or on the joint continuance of any number of lives, that is, an annuity which is to be paid during a certain term, provided that the single life or the other lives jointly subsist so long; together with an annuity on the same life or lives *deferred* for the same term, are evidently equivalent to an annuity on the whole duration of the same life or lives.

So that the value of an annuity on any life or on the joint continuance of any number of lives for an assigned term, is equal to the excess of the value of an annuity on their whole duration, with immediate possession, above the value of an annuity on them deferred for the term.

59. Whatever has been advanced from No. 48. to 53. inclusive, respecting the values of annuities for the whole duration of the lives whereon they depend, will apply equally to those which are either deferred or temporary; and, therefore, to determine the value of any deferred or temporary annuity, dependent upon the last survivor of two or of three lives; or, upon the joint continuance of the last two survivors out of three lives; we have only to substitute temporary or deferred annuities, as the case may require, for annuities on the whole duration of the lives; and the result will, accordingly, be the value of a temporary or deferred annuity on the life of the last survivor, or on the joint lives of the two last survivors.

60. *Prop.* 5. *A* and *B* being any two proposed lives now in existence, the present value of an annuity to be payable only while A survives B, is equal to the excess of the value of an annuity on the life of A, above that of an annuity on the joint existence of both the lives.

61. *Demons.* If an annuity on the life of *A*, and to be entered upon immediately, were now granted to *P*, upon condition that he should pay it to *B* during the joint lives of *A* and *B*; it is evident that there would only remain to *P*, an annuity on the life of *A* after the decease of *B*: whence the truth of the proposition is manifest.

62. When any thing is affirmed or demonstrated of *any life or lives*, it is to be understood as applying equally to any proposed single life, or to the joint continuance of the whole of any number of lives that may be proposed together, or to that of any assigned number of the last survivors of them, or to the last surviving life of the whole.

63. *Prop.* 6. The present value of the reversion of a perpetual annuity after the failure of any life or lives, is equal to the excess of the present value of the perpetuity with immediate possession, above the present value of an annuity on the same life or lives.

64. *Demons.* If a perpetual annuity with immediate possession were granted to *P*, upon condition that he should pay the annual produce to another individual, during the existence of the life or lives proposed; it is evident that there would only remain to *P*, the reversion after the failure of such life or lives; and the present value of that reversion would manifestly be as stated above.

65. The 6th, 7th, and 8th tables at the end of this article, which have been extracted from the 19th, 21st, and 22d, respectively, in Mr Milne's *Treatise on Annuities*, will serve to illustrate the application of these propositions to the solution of questions in numbers.

In all the following examples, we suppose the lives to be such, as the general average of those the Carlisle table of mortality was constructed from, and the rate of interest to be *5 per cent*.

66. *Ex.* 1. What is the present value of an annuity on the joint lives, and the life of the survivor of two persons now aged 40 and 50 years respectively?

According to No. 48, the process is as follows:

| | | | |
|---|---|---|---|
| Value of a single life of | 40 | 13·390 | by Table VI. |
| | 50 | 11·660 | |
| | sum | 25·050 | |
| Subtract the value of their joint lives, | | 9·984 | (Table VIII.) |
| | remains | 15·066 | years' purchase, |

the required value.

And if the annuity be L. 200, its present value will be L. 3013·2, or L. 3013, 4s.

67. *Ex.* 2. The lives *A*, *B*, and *C*, being now aged 50, 55, and 60 years respectively, an annuity on the joint continuance of all the three, is worth 6·289 years purchase; What is the value of an annuity on the joint existence of the last two survivors of them?

According to No. 50, the process is thus:

| Ages. | Values. | |
|---|---|---|
| 50 & 55 | 8·528 | Table VII. |
| 55 & 60 | 7·106 | |
| 50 & 60 | 7·601 | Table VIII. |

sum 23·235

Subtract $2 \times 6{\cdot}289 = 12{\cdot}578$

remains 10·657 years' purchase, the required value.

Therefore, if the annuity were L. 300, it would be worth L. 3197, 2s. in present money.

68. *Ex.* 3. Required the value of an annuity on the last survivor of the three lives in the last example.

Proceeding according to No. 52, we have

| Ages. | Values. | |
|---|---|---|
| 50 | 11·660 | Tab. VI. |
| 55 | 10·347 | |
| 60 | 8·940 | |
| 50, 55, & 60 | 6·289 | (No. 67). |
| sum | 37·236 | |
| Subtract the sum of the values of annuities on the three combinations of two lives, | 23·235 | (No. 67.) |
| remains | 14·001 | years' purchase, |

the required value. And if the annuity were L. 300, it would now be worth L. 4200, 6s.

69. *Ex.* 4. What is the present value of an annuity on a life now 45 years of age, which is not to be entered upon until the expiration of ten years; the first payment thereof being to be made at the expiration of eleven years from this time, if the life survive till then?

*Solution.*

The present value of an annuity on a life of 55 is 10·347 (Table VI.), and the present value of L. 1 to be received upon the proposed life attaining to the

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age of 55, is $\frac{4073}{4727} \times 0{\cdot}613913$; therefore, by No. 55, the required value is $\frac{4073 \times 0{\cdot}613913 \times 10{\cdot}347}{4727}$ $= 5{\cdot}473$ years purchase; so that if the annuity were L. 200, its present value would be L. 1094, 12s.

70. *Ex.* 5. Required the present value of an annuity to be received for the next ten years, provided that a person now 45 years of age, shall so long live.

*Solution.*

The present value of an annuity on a life of 45, to be entered upon immediately, is 12·648 (Table VI.)

| | |
|---|---|
| Subtract that of an annuity on the same life deferred 10 years, | 5·473 (69). |
| the remainder, | 7·175 |

is the required number of years purchase. And, if the annuity were L. 200, its present value would be L. 1435.

71. *Ex.* 6. An annuity on a life of 45, deferred 10 years, was shown in No. 69, to be worth 5·473 years purchase in present money; let it be required to determine the equivalent annual payment for the same, to be made at the end of each of the next 10 years, but subject to failure upon the life failing in the term.

*Solution.*

The present value of L. 1 *per annum* on the proposed life for the next 10 years, has just been shown to be L. 7·175, and this, multiplied by the required annual payment, must produce L. 5·473; that payment must, therefore, be $\frac{5{\cdot}473}{7{\cdot}175} = 0{\cdot}76279$. And, since the annual payment for the deferred annuity of L. 1 *per annum* would be L. 0·76279, that for an annuity of L. 200 must be L. 152, 11s. 2d.

72. *Ex.* 7. Let the present value be required of an annuity on a life now 40 years of age, to be payable only while that life survives another now of the age of 50 years.

| | |
|---|---|
| From the present value of a life of 40, | 13·390 (Table VI.) |
| Subtract that of the two joint lives, | 9·984 (Table VIII.) |
| the remainder, | 3·406 |

years purchase is the required value (60).

Therefore, if the annuity were L. 100, it would be worth L. 340, 12s. in present money.

73. If the annuity in the last example were to be paid for by a constant annual premium at the end of each year while both the lives survived; by reasoning as in No. 71, it will be found, that such annual premium for an annuity of L. 1 should be $\frac{3{\cdot}406}{9{\cdot}984} =$ L. 0·341146; for an annuity of L. 100 it should therefore be L. 34, 2s. 3½d.

74. But if one of the equal premiums for this annuity is to be paid down now, and another at the end of each year while both the lives survive; the number of years purchase the whole of these premiums are worth, will evidently be increased by unity, on account of the payment made now, it will, therefore, be 10·984; and each premium for an annuity of L. 1 must, in this case, be $\frac{3{\cdot}406}{10{\cdot}984} =$ L. 0·310087; for an annuity of L. 100 it should, therefore, be L. 31, 0s. 2d.

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75. *Ex.* 8. Let it be required to determine the present value of the reversion of a perpetual annuity after the failure of a life now 50 years of age.

*Solution.*

The value of the perpetuity is 20 years purchase (8.)

| | |
|---|---|
| Subtract that of an annuity on the life of 50, | 11·660 (Table VI.) |
| | Remains 8·34 years purchase, the required value of the reversion (63.) |

So that if the annuity were L. 300, its present value would be L. 2502.

76. In the same manner it will be found, by the 68th number and those referred to in the last example, that the reversion of a perpetuity, after the failure of the last survivor of three lives, now aged 50, 55, and 60 years respectively, is worth 5·999 years purchase in present money; therefore, if it were L. 100 *per annum*, its present value would be L. 599, 18s.

## III. OF ASSURANCES ON LIVES.

77. An assurance upon a life, or lives, is a contract by which the Office or Underwriter, in consideration of a stipulated premium, engages to pay a certain sum upon such life or lives failing within the term for which the assurance is effected.

78. If the term of the assurance be the whole duration of the life or lives assured, the sum must necessarily be paid whenever the failure happens; and, in what follows, that payment is always supposed to be made at the end of the year in which the event assured against takes place. The anniversary of the assurance, or the day of the date of the policy, being accounted the beginning of each year.

79. At the end of the year in which any proposed life or lives may fail, the proprietor of the reversion of a perpetual annuity of L. 1 after their failure, will receive the pound then due, and will, at the same time, enter upon the perpetuity; therefore, the present value of the reversion is the same as that of L. 1 added to the money a perpetual annuity of L. 1 would cost, supposing this sum not to be receivable until the expiration of the year in which the failure of the life or lives might happen.

80. Hence we have this proportion. As the value of a perpetuity increased by unity is to L. 1, so is the present value of the reversion of a perpetual annuity of L. 1, after the failure of any life or lives, to the present value of L. 1, receivable at the end of the year in which such failure shall take place.

81. Therefore, *if the value of an annuity of one pound on any life or lives, be subtracted from that of the perpetuity, and the remainder be divided by the value of the perpetuity increased by unity; the quo-*

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*tient will be the value, in present money, of the assurance of one pound on the same life or lives.* (63)

82. *Ex.* 1. What is the present value of L. 1, to be received at the end of the year, in which a life now 50 years of age may fail?

The rate of interest being 5 *per cent.* the value of the perpetuity is 20 years purchase, and that of the life 11·66; the answer therefore is $\frac{20-11{\cdot}66}{20+1}=\frac{8{\cdot}34}{21}=$ L. 0·397143. And if the sum assured were L. 1000, the present value of the assurance would be L. 397, 2s. 10d.

83. When the term of a life assurance exceeds one year, its whole value is hardly ever paid down at the time that the contract is entered into, but, in the instrument (called a Policy) whereby the assurance is effected, an equivalent annual premium is stipulated for, payable at the *commencement* of each year during the term, but subject to failure with the life or lives assured.

84. But by reasoning as in No. 74, it will be found, that an annual premium payable at the *commencement* of each year in the whole duration of the life or lives assured, will be worth one year's purchase more, than an annuity on them payable at the *end* of each year; and, consequently, that if the value in present money of an assurance on any life or lives, be divided by the number of years purchase an annuity on the same life or lives is worth, increased by unity, the quotient will be the equivalent annual premium for the same assurance.

85. *Ex.* 2. Required the annual premium for the assurance of L. 1, on a life of 50 years of age.

In No. 82, the single premium for that assurance was shown to be 0·397143, and the value of an annuity on the life is 11·66, therefore, by the preceding number, the required annual premium will be $\frac{0{\cdot}397143}{12{\cdot}66}=$ ·0313699 for the assurance of L. 1; and for the assurance of L. 1000, it will be L. 31, 7s. 5d.

86. *Ex.* 3. Let both the single payment in present money, and the equivalent annual premium be required for the assurance of L. 1, on the joint continuance of two lives of the respective ages of 45 and 50 years.

The value of an annuity of L. 1 on the joint continuance of these two lives, appears by Table VII. to be L. 9·737, therefore $\frac{20-9{\cdot}737}{20+1}=\frac{10{\cdot}263}{21}=$ L. 0·488714 is the single premium, and $\frac{0{\cdot}488714}{10{\cdot}737}=$ L. 0·0455168, the equivalent annual one for the assurance of L. 1 to be paid at the end of the year, in which that life becomes extinct which may happen to fail the first of the two.

Therefore, if the sum assured were L. 500, the total present value of the assurance would be L. 244, 7s. 2d. and the equivalent annual premium L. 22, 15s. 2d.

87. *Ex.* 4. Let both the single and the equivalent annual premium be required for the assurance of L. 1, on the life of the survivor of two persons now aged 40 and 50 years respectively.

The value of an annuity on the survivor of these two lives was shown in No. 66, to be 15·066, therefore, by No. 81, the single premium will be $\frac{20-15{\cdot}066}{20+1}=\frac{4{\cdot}934}{21}=$ L. 0·234952; and by No. 84, the annual one will be $\frac{\text{L. } 0.234952}{16{\cdot}066}=$ L. 0·0146242.

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That is, for the assurance of L. 1 to be received at the end of the year, in which the last surviving life of the two becomes extinct.

Therefore, for the assurance of L. 5000, the single premium will be L. 1174, 15s. 2d. the equivalent annual one L. 73, 2s. 5d.

88. *Ex.* 5. What should the single and equivalent annual premiums be for an assurance on the last survivor of three lives, of the respective ages of 50, 55, and 60 years.

The value of an annuity on the last survivor of them, was shown in No. 68, to be 14·001, the single premium should therefore be $\frac{20-14{\cdot}001}{20+1}=\frac{5{\cdot}999}{21}$ = L. 0·285666, and the annual $\frac{\text{L. } 0{\cdot}285666}{15{\cdot}001}=$ L. 0·0190431, for the assurance of L. 1, to be received at the end of the year, in which the last surviving life of the three may fail.

For the assurance of L. 2000, the single premium would therefore be L. 571, 6s. 8d. the annual one L. 38, 1s. 9d.

89. *Lemma.* If an annuity be payable at the *commencement* of each year, which some assigned life or lives may *enter upon* in a given term; the number of years purchase in its present value, will exceed by unity the number of years purchase, in the present value of an annuity on the same life or lives for one year less than the given term, but payable as annuities generally are, at the *end* of each year.

*Demonstration.* Since the proposed life or lives can only enter upon any year after the first, by surviving the year that precedes it; the receipt of each of the payments after the first, that are to be made at the commencement of the year, will take place at the same time, and upon the same conditions as that of the rent for the year then expired of the life-annuity, for a term one year less than the term proposed: this last mentioned annuity, will therefore, be worth in present money, just the same number of years' purchase as all the payments subsequent to the first, which may be made at the commencements of the several years.

And, since the first of these is to be made immediately, the present value of the whole of them, will evidently exceed the number of years purchase last mentioned, by unity, which was to be demonstrated.

90. If, while the rest remains the same, the payment of the annuity which depends upon the assigned life or lives *entering upon* any year, is not to be made until the end of that year; as the condition upon which every payment is to be made, will remain the same, but each of them will be one year later; the only alteration in the value of the whole, will arise from this increase in the remoteness of payment, by which it will be reduced in the ratio of L. 1, to the present value of L. 1, receivable at the end of a year (2).

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91. When the value of an annuity on any proposed life or lives for an assigned term is given, it is evident that the value of an annuity on the same life or lives for one year less may be found, by subtracting from the given value, the present value, of the rent to be received upon the proposed life or lives surviving the term assigned.

92. *Proposition.* The present value of an assurance on any proposed life or lives for a given term, is equal to the excess of the value of an annuity to be paid at the end of each year, which the life or lives proposed may *enter upon* in the term, above the value of an annuity on them for the same term, but dependent, as usual, upon their surviving each year.

*Demonstration.* If an annuity payable at the end of each year, which the proposed life or lives may enter upon during the given term, be granted to $P$, upon condition that he shall pay over what he receives to $Q$, at the end of each year which the same life or lives may survive; it is manifest that there will only remain to $P$, the rent for the year in which the proposed life or lives may fail; that is, the assurance of that sum thereon for the given term (77). Which was to be demonstrated.

93. From the last four numbers (89—92) we derive the following

Rule

for determining the present value of an assurance on any life or lives for a given term.

*Add unity to the value of an annuity on the proposed life or lives for the given term, and from the sum subtract the present value of one pound, to be received upon the same life or lives surviving the term; multiply the remainder by the present value of L. 1, to be received certainly at the end of a year, and from the product subtract the present value of an annuity on the proposed life or lives for the term.*

This last remainder will be the value in present money of the assurance of L. 1 during the same term, on the life or lives proposed.

94. It has been shown above (34—39), how the present value of L. 1, receivable upon any single or joint lives surviving an assigned term, may be found. And all that was demonstrated from No. 48. to 53. inclusive, respecting annuities on the last survivor of two, or of three lives, or on the joint continuance of the two last survivors out of three lives, is equally true of any particular year's rent of those annuities. Hence it is evident, how the present value of L. 1, to be received upon the last survivor of two, or of three lives, or upon the last two survivors out of three lives, surviving any assigned term, may be found.

95. *Example.* Required the present value of L. 1, to be received at the end of the year, in which a life, now forty-five years of age, may fail, provided that such failure happens before the expiration of ten years.

Here the present value of L. 1, to be received upon the life surviving the term, will be found to be L. 0·528976, and the value of an annuity on the proposed life for the term, is 7·175 (70.)

From 8·175
subtract 0·528976

the remainder 7·646024
being multiplied by 0·952381

produces 7·28193
from this subtract 7·17500

remains L. 0·10693, the required value of the assurance; and if the sum assured were L. 3000, the value of the assurance in present money would be L. 320, 15s. 7d.

96. By numbers 89, 91, and 95, it appears, that an annuity, payable at the commencement of each of the next ten years that a life of 45 enters upon, is worth 7·646 years purchase: therefore, $\frac{0\cdot10693}{7\cdot646} =$ L. 0·013985 will be the annual premium for the assurance of L. 1 for ten years on that life. For the assurance of L. 3000, it will therefore be L. 41, 19s. 1d.

97. When the term of the assurance is the whole duration of the life or lives assured, L. 1 to be received upon their surviving the term is worth nothing; and an annuity on the lives for the term, is also for their whole duration.

Therefore, from No. 93. we derive the following

Rule

for determining the present value of an assurance on any life or lives.

*Add unity to the value of an annuity on the proposed life or lives; multiply the sum by the present value of L. 1, to be received certainly at the end of a year; and from the product, subtract the value of an annuity on the same life or lives.*

The remainder will be the value of the assurance in present money.

98. *Example.* Required the present value of L. 1, to be received at the end of the year, in which the survivor of two lives may fail, their ages now being 40 and 50 years respectively.

The value of an annuity on these lives was shown in No. 66. to be 15·066.

Multiply 15·066 by 0·952381, from the product 15·3009, subtract 15·066, the remainder L. 0·2349 is the required value, agreeably to No. 87.

And, in all other cases, the values determined by the rule in the preceding number, will be found to agree with those obtained by the method of No. 81.

99. When an assurance on any life or lives has been effected at a constant annual premium, and kept up for some time, by the regular payment of that premium; the annual premium required for a new assurance of the same sum on the same life or lives, will, on account of the increase of age, be greater than that at which the first assurance was effected: Therefore, the present value of all these greater annual premiums, that is, the total present value of the new assurance, will exceed the present value of all the premiums that may hereafter be received under the existing policy. And the excess

will evidently be the value of the policy, supposing the life or lives to be still insurable; that being the only advantage that can now be derived from the premiums already paid.

So that, if the present value of all the future annual premiums to be paid under an existing policy for the assurance of a certain sum upon any life or lives, be subtracted from the present value of the assurance of the same sum on the same life or lives; the remainder will be the value of the policy.

100. *Example.* L. 1000 has been assured some years, on a life now 50 years of age, for its whole duration, at the annual premium of L. 20, one of which has just now been paid: What is the value of the policy?

The present value of the assurance of L. 1000 on that life, has been shown in No. 82. to be L. 397, 2s. 10d.; and an annuity on the life, being worth 11·66 years purchase (Table VI.), the present value of all the premiums to be paid in future under the existing policy, is $11{\cdot}66 \times$ L. $20 =$ L. 233, 4s. 0d.; the value of the policy, therefore, is L. 163, 18s. 10d.

Immediately before the payment of the premium, the value of the policy would evidently have been less by the premium then due.

101. In our investigations of the values of annuities on lives, we have hitherto assumed, that no part of the rent is to be received for the year in which the life wherewith the annuity may terminate fails.

But if a part of the annuity is to be received at the end of that year, proportional to the part of the year which may have elapsed at the time of such failure; as, in a great number of such cases, some of the lives wherewith the annuity terminates will fail in every part of the year, and as many, or very nearly so, in any one part of it as in any other: we may assume, that, upon an average, half a year's rent will be received at the end of the year in which such failure happens; and, therefore, that by the title to what may be received after the failure of the life or lives whereon the annuity depends, the present value of that annuity will be increased by the present value of the assurance of half a year's rent on the same life or lives.

102. Thus, for example: the present value of the assurance of L. 1 on a life of 50 years of age, having in No. 82. been shown to be L. 0·397143, the value of an annuity of L. 1 on that life, when payable, till the last moment of its existence, will exceed L. 11·66, its value, if only payable, until the expiration of the last year it survives, by $\left(\frac{\text{L. } 0{\cdot}397143}{2} =\right)$ L. 0·199; it will therefore be L. 11·859.

103. If, at the end of the year in which an assigned life $A$ may fail, $Q$ or his heirs are to receive L. 1; and are, at the same time, to enter upon an annuity of L. 1, to be enjoyed during another life $P$, to be then fixed upon: the present value of $Q$'s interest will evidently be the same as that of the assurance on the life of $A$, of a number of pounds, exceeding by unity the number of years purchase in the value of an annuity on the life of $P$, at the time of nomination.

104. What is the present value of the next presentation to a living of the clear annual value of L. 500; $A$, the present incumbent, being now 50 years of age; supposing the age of the clerk presented to be 25, at the end of the year in which the present incumbent dies; also, that he takes the whole produce of the living for that year?

By Table VI. it will be found, that the value of an annuity of L. 1 on a life of 25, is L. 15·303; and in No. 82. it has been shown, that the present value of the assurance of L. 1 on a life of 50, is L. 0·397143. Hence, and by the last number, it appears, that if the annual produce of the living were but L. 1, the present value of the next presentation would be L. $16{\cdot}303 \times 0{\cdot}397143 =$ L. 6·47467. The required value, therefore, is L. 3237, 6s. 9d.

105. If, to the value of the succeeding life, determined according to No. 103, the value of the present be added, the sum of these will evidently be the present value of both the lives in succession; and, in the case of the preceding number, will be $6{\cdot}475 + 11{\cdot}66 = 18{\cdot}135$ years' purchase.

106. In No. 103, we proceeded upon the supposition that the annuity on the present life is only payable up to the expiration of the last year it survives; and, consequently, that the succeeding life takes the whole rent for the year in which the present fails.

But, if the succeeding life is only to take a part of that rent, in the same proportion to the whole, as the portion of the year which intervenes between the failure of the present life and the end of the year, is to the whole year, then, by reasoning as in No. 101, it will be found, that the portion of that rent which the succeeding life will receive, may be properly assumed to be one half. And, instead of increasing the number of years' purchase the annuity on the succeeding life will be worth at the end of the year in which the other fails, by unity, we must only add one half to that number, in order that the present value of the assurance of the sum on the existing life, may be the number of years' purchase, which all that may be received during the succeeding life, is now worth.

107. The value of the succeeding life, in the case of No. 104, will, upon this hypothesis, be $15{\cdot}803 \times 0{\cdot}397143 = 6{\cdot}27605$ years' purchase.

And this appears to be the most correct way of calculating the value of an annuity on a succeeding life; although that of No. 103. proceeds upon the principle on which life interests are generally valued.

108. But the value of two lives in succession, will be the same on both hypotheses. The rent for the year in which the first may fail, being, in the one case, given entirely to the successor; and, in the other, divided equally between the two.

This is also true of any greater number of successive lives.

## PART II.

109. We now proceed to treat the subject of Annuities *Algebraically*.

### I. ON ANNUITIES CERTAIN.

Let $r$ denote the *simple interest* of L. 1 for one year.
$s$, any *sum* put out at interest.
$n$, the *number of years* for which it is lent.
$m$, its *amount* in that time.
$a$, an *annuity* for the same time (3 and 4.)
M, the *amount* to which that *annuity* will increase, when each payment is laid up as it becomes due, and improved at compound interest until the end of the term.
V, the *present value* of the same annuity (6.)

110. Then, reasoning as in the first number of this article, it will be found that $m = s(1+r)^n$. And by No. 2. it appears, that the present value of $s$ pounds to be received certainly at the expiration of $n$ years, is $s\frac{1}{(1+r)^n}$, or $s(1+r)^{-n}$.

111. The amount of L. 1 in $n$ years being $(1+r)^n$, its increase in that time will be $(1+r)^n-1$, and when it is considered that this increase arises entirely from the simple interest ($r$) of L. 1 being laid up at the end of each year, and improved at compound interest during the remainder of the term; it must be obvious that $(1+r)^n-1$ is the amount of an annuity of $r$ pounds in that time, but $r : a :: (1+r)^n-1 : \frac{a}{r}\left[(1+r)^n-1\right]$, which, therefore, is equal to M, the amount of an annuity of $a$ pounds in $n$ years.

112. Reasoning as in No. 8. it will be found, that since $r : 1 :: a : \frac{a}{r}$, the present value of a perpetual annuity of $a$ pounds is $\frac{a}{r}$.

113. If two persons, $A$ and $B$, purchase a perpetuity of $a$ pounds between them, which $A$ and his heirs or assigns are to enjoy during the first $n$ years, and $B$, and his heirs and assigns, for ever after. Since the value of the perpetuity to be entered upon immediately, has just been shown to be $\frac{a}{r}$, the present value of $B$'s share, that is, the present value of the same perpetuity when the entrance thereon is deferred until the expiration of $n$ years, will be $\frac{a}{r}(r+1)^{-n}$, (110); and the value of the share of $A$ will be thus much less than that of the whole perpetuity (21), and therefore equal to $\frac{a}{r}\left[1-(1+r)^{-n}\right] = \text{V}$, the present value of an annuity of $a$ pounds for the term of $n$ years certain.

114. If the annuity is not to be entered upon until the expiration of $d$ years, but is then to continue $n$ years, its value at the time of entering upon it will be $\frac{a}{r}\left[1-(1+r)^{-n}\right]$, as has just been shown; therefore its present value will be

$$\frac{a}{r}\left[(1+r)^{-d}-(1+r)^{-(d+n)}\right] = \text{V}, \ (110.)$$

115. In the same manner, it appears that, when the entrance on a perpetuity of $a$ pounds is deferred $d$ years, its present value will be $\frac{a}{r}(1+r)^{-d}$ (110 and 112.)

116. $q$ being any number whatever, whole, fractional, or mixed, let $\lambda q$ denote its logarithm, and $\kappa q$ the arithmetical complement of that logarithm; so that these equations may obtain, $\lambda\frac{1}{q} = -\lambda q = \kappa q$.

Then, for the resolution of the principal questions of this kind by logarithms, we shall have these formulæ.

1. *Amount of a sum improved at interest.*
$$\lambda m = n\lambda(1+r) + \lambda s, \ (110.)$$

2. *Amount of an annuity when each payment is laid up as it becomes due, and improved at interest until the expiration of the term.*
$$\lambda \text{M} = \lambda\left[(1+r)^n-1\right] + \lambda a + \kappa r, \ (111.)$$

3. *Value of a lease or an annuity.*
$$\lambda \text{V} = \lambda\left[1-(1+r)^{-n}\right] + \lambda a + \kappa r \ (113.)$$

4. *Value of a deferred annuity, or the renewal of any number of years lapsed in the term of a lease.*
$$\lambda \text{V} = \lambda\left[(1+r)^{-d}-(1+r)^{-(d+n)}\right] + \lambda a + \kappa r, (114.)$$

5. *Value of a deferred perpetuity, or the reversion of an estate in fee simple, after an assigned term.*
$$\lambda \text{V} = \lambda a + \kappa r + d\kappa(1+r), \ (115).$$

By means of each of these equations, it is manifest that any one of the quantities involved in it may be found, when the rest are given.

117. If the interest be convertible into principal $\nu$ times in the year, at $\nu$ equal intervals, since the interest of L. 1 for one of these intervals will be $\frac{r}{\nu}$, (109), and the number of conversions of interest into principal in $n$ years $\nu n$; to adapt the formula in No. 110. to this case, we have only to substitute $\frac{r}{\nu}$ for $r$, and $\nu n$ for $n$, in the equation $m = s(1+r)^n$ there given, whereby it will be tranformed to this, $m = s\left(1+\frac{r}{\nu}\right)^{\nu n}$.

118. According as $\nu$ is equal to 1, 2, 4, or is infinite; that is, according as the interest is convertible into principal yearly, half-yearly, quarterly, or continually, let $m$ be equal to Y, H, Q, or C; so shall

$$Y = s(1+r)^n,$$

$$H = s\left(1+\frac{r}{2}\right)^{2n},$$

$$Q = s\left(1+\frac{r}{4}\right)^{4n},$$

and $C = s \cdot N$

N being the number whereof $nr$ is the hyperbolic logarithm, and $nr \times 0{\cdot}43429448$ its logarithm in Briggs' *System*, and the common tables.

119. From No. 117 and 110, it follows, that the present value of $s$ pounds to be received at the end of $n$ years, when the interest is convertible into principal at $\nu$ equal intervals in each year, is $s\left(1+\frac{r}{\nu}\right)^{-\nu n}$.

120. When the present values and the amounts of annuities are desired, let the interest be convertible into principal at $\nu$ equal intervals in the year, while the annuity is payable at $\pi$ intervals therein, the amount of each payment being $\frac{a}{\pi}$.

121. *Case* I. $\mu$ being any whole number not greater than $\nu$, let $\frac{1}{\pi}=\frac{\mu}{\nu}$, so that the interest may be convertible into principal $\mu$ times in each of the intervals between the payments of the annuity.

Then will the amount of L. 1, at the expiration of the period $\frac{1}{\pi}$ be $\left(1+\frac{r}{\nu}\right)^{\mu}$ (117), and the interest of L. 1 for the same time will be $\left(1+\frac{r}{\nu}\right)^{\mu}-1$; whence the present value of the perpetuity will be $\dfrac{\frac{1}{\pi}a}{\left(1+\frac{r}{\nu}\right)^{\mu}-1}$ (8), and the value of the same deferred $n$ years, will be $\frac{a}{\pi}\cdot\dfrac{\left(1+\frac{r}{\nu}\right)^{-\nu n}}{\left(1+\frac{r}{\nu}\right)^{\mu}-1}$ (119), therefore the present value of the annuity to be entered upon immediately, and to continue $n$ years, will be

$$\frac{a}{\pi}\cdot\frac{1-\left(1+\frac{r}{\nu}\right)^{-\nu n}}{\left(1+\frac{r}{\nu}\right)^{\mu}-1}=\text{V}.$$

122. *Case* 2. $\mu$ being any whole number greater than $\pi$, let $\frac{1}{\nu}=\frac{\mu}{\pi}$, so that the annuity may be payable $\mu$ times in each of the intervals between the payments of interest, or the conversion thereof into principal.

Then, at the expiration of the $\frac{1}{\nu}$th of a year, when the interest on the purchase-money is first payable or convertible, the interest on all the $\mu-1$ payments of the annuity previously made, will be

$$\frac{ar}{\pi\pi}\left[(\mu-1)+(\mu-2)+(\mu-3)+\ldots\ldots+3+2+1\right]$$

$=\frac{a}{\pi}\cdot\frac{r\mu(\mu-1)}{2\pi}$; to which, adding the $\mu$ payments of $\frac{a}{\pi}$ each (including the one only then due), the sum, $\frac{a}{\pi}\left[\mu+\frac{r\mu(\mu-1)}{2\pi}\right]$, is the simple interest which the value of the perpetuity should yield at the expiration of each $\nu$th part of a year, in order to supply the deficiency (both of principal and interest) that would be occasioned during each of those periods, in any fund out of which the several payments of the annuity might be taken, as they respectively became due; and since $\frac{r}{\nu}:\frac{a}{\pi}\left[\mu+\frac{r\mu(\mu-1)}{2\pi}\right]::1:\frac{a\nu}{r\pi}\left[\mu+\frac{r\mu(\mu-1)}{2\pi}\right]=a\left(\frac{1}{r}+\frac{\mu-1}{2\pi}\right)$, this last expression will be the value of such perpetuity with immediate possession (8); the value of the same deferred $n$ years, will therefore be $a\left(\frac{1}{r}+\frac{\mu-1}{2\pi}\right)\times\left(1+\frac{r}{\nu}\right)^{-\nu n}$ (119). Whence it appears, that the present value of the annuity to be entered upon immediately, and to continue $n$ years, will be

$$a\left(\frac{1}{r}+\frac{\mu-1}{2\pi}\right)\cdot\left[1-\left(1+\frac{r}{\nu}\right)^{-\nu n}\right]=\text{V}.$$

123. *Case* 3. When, in consequence of the annuity being always payable at the same time that the interest is convertible, $\nu=\pi$.

Since the interest of L. 1 at the expiration of the period $\frac{1}{\pi}$ will be $\frac{r}{\pi}$, the value of the perpetuity will be $\dfrac{\frac{1}{\pi}a}{\frac{1}{\pi}r}=\frac{a}{r}$ (8), whence, proceeding as before, we obtain the present value of the annuity,

$\frac{a}{r}\left[1-\left(1+\frac{r}{\nu}\right)^{-\nu n}\right]=\text{V}$. When $\nu=\pi$, and consequently $\mu=1$, the values of V, given in the two preceding cases, will be found to coincide with this.

124. According as $\nu$ and $\pi$ are each equal to 1, 2, 4, or are infinite; that is, according as the interest and the annuity are each payable yearly, half-yearly, quarterly, or continually, let V be equal to $y$, $h$, $q$, or $c$, then will

$$y=\frac{a}{r}\left[1-(1+r)^{-n}\right],$$

$$h=\frac{a}{r}\left[1-\left(1+\frac{r}{2}\right)^{-2n}\right],$$

$$q=\frac{a}{r}\left[1-\left(1+\frac{r}{4}\right)^{-4n}\right],$$

and $c=\frac{a}{r}\left[1-\frac{1}{\text{N}}\right]$, N being as in No. 118.

125. The amount of an annuity is equal to the sum to which the purchase money would amount, if it were put out and improved at interest during the whole term.

For, from the time of the purchase of the annuity, whatever part of the money that was paid for it may be in the hands of the grantor, he must improve thus to provide for the payments thereof; and if the purchaser also improve in the same manner all he receives, the original purchase money must evident-

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ly receive the same improvement during the term, as if it had been laid up at interest at its commencement.

126. The periods of conversion of interest into principal, and of the payment of the annuity being still designated as in No. 120; since in $n$ years, the number of periods of conversion will be $\nu n$, in the

1*st Case*, Where the interest is convertible $\mu$ times in each of the intervals between the payments of the annuity, we have $\left(1+\frac{r}{\nu}\right)^{\nu n}\text{v}=\frac{a}{\pi}\cdot\frac{\left(1+\frac{r}{\nu}\right)^{\nu n}-1}{\left(1+\frac{r}{\nu}\right)^{\mu}-1}$ $=\text{M}$, (117, 121, and 125). In the 2*d Case*, when the annuity is payable $\mu$ times, in each interval between the conversions of interest,

$$\left(1+\frac{r}{\nu}\right)^{\nu n}\text{v}=a\left[\frac{1}{r}+\frac{\mu-1}{2\pi}\right]\cdot\left[\left(1+\frac{r}{\nu}\right)^{\nu n}-1\right]$$

$=\text{M}$, (117, 122, and 125).

And, in the 3*d Case*, when the annuity is always payable at the same time that the interest is convertible, $\left(1+\frac{r}{\nu}\right)^{\nu n}\text{v}=\frac{a}{r}\left[\left(1+\frac{r}{\nu}\right)^{\nu n}-1\right]=\text{M}$,(117, 123, and 125).

127. According as $\nu$ and $\pi$ are each equal to 1, 2, 4, or are infinite; that is, according as the interest and the annuity are each payable yearly, half-yearly, quarterly, or continually, let M be denoted by $y'$, $h'$, $q'$, or $c'$;

then will $\quad y'=\frac{a}{r}\left[(1+r)^{n}-1\right]$,

$$h'=\frac{a}{r}\left[\left(1+\frac{r}{2}\right)^{2n}-1\right],$$

$$q'=\frac{a}{r}\left[\left(1+\frac{r}{4}\right)^{4n}-1\right],$$

and $c'=\frac{a}{r}(\text{N}-1)$; N being as in No. 118.

128. *Example* 1. What will L.320 amount to, when improved at compound interest during 40 years; the rate of interest being 4 *per cent. per annum?*

By the first formula in No. 116, the operation will be as follows:

$$\begin{aligned} 1+r&=1{\cdot}04\ \lambda\ 0{\cdot}01703334\\ &\qquad\times n=40\\ (1+r)^n&\ \lambda\ 0{\cdot}6813336\\ s&=320\ \lambda\ 2{\cdot}5051500\\ m&=1536{\cdot}327\ \lambda\ 3{\cdot}1864836 \end{aligned}$$

And the answer is L.1536, 6s. 6½d.

129. *Ex.* 2. If the interest were convertible into principal every half-year, the operation, according to No. 117, would be thus:

$$\begin{aligned} 1+\frac{r}{2}&=1{\cdot}02\ \lambda\ 0{\cdot}00860017\\ &\qquad\times \nu n=80\\ &\quad 0{\cdot}6880136\\ s&=320\ \lambda\ 2{\cdot}5051500\\ m&=1560.14\ \lambda\ 3{\cdot}1931636 \end{aligned}$$

So that in this case the amount would be L.1560, 2s. 9½d.

130. *Ex.* 3. Required the present value of an annuity of L.250 for 30 years, reckoning interest at 5 *per cent.*

By the third formula in No. 116, the operation will be thus:

$$\begin{aligned} \lambda\ (1+r)^{-1}&=\kappa\ 1{\cdot}05=\bar{1}{\cdot}9788107\\ &\qquad\times n=30\\ (1+r)^{-n}&={\cdot}23137704\ \lambda\ \bar{1}{\cdot}3643210\\ 1-(1+r)^{-n}&={\cdot}76862296\ \lambda\ \bar{1}{\cdot}8857133\\ a&=250\ \lambda\ 2{\cdot}3979400\\ r&={\cdot}05\ \kappa\ 1{\cdot}3010300\\ \text{v}&=3843{\cdot}114\ \lambda\ 3{\cdot}5846833 \end{aligned}$$

And the required value is L.3843, 2s. 3¼d.

131. *Ex.* 4. The rest being still the same, if the annuity in the last example be payable half-yearly, in the formula of No. 122, $\nu$ will be equal to 1, $\pi=2$, and $\mu=2$; that formula will therefore become $a\left(\frac{1}{r}+\frac{1}{4}\right)\cdot\left[1-(1+r)^{-n}\right]=\text{v}$; and the operation will be thus:

$$\begin{aligned} \left.\begin{aligned}1-(1+r)^{-n}&\ \lambda\ \bar{1}{\cdot}8857133\\ a=250&\ \lambda\ 2{\cdot}3979400\end{aligned}\right\}&\ \text{No. 130.}\\ \frac{1}{r}+\frac{1}{4}&=20{\cdot}25\ \lambda\ 1{\cdot}3064250\\ \text{v}&=3891{\cdot}15\ \lambda\ 3{\cdot}5900783 \end{aligned}$$

The value of the annuity will, therefore, in this case, be L. 3891, 3s.

132. *Ex.* 5. To what sum will an annuity of L. 120 for 20 years amount, when each payment is improved at compound interest, from the time of its becoming due until the expiration of the term; the rate of interest being 6 *per cent.?*

The operation by the second formula in No. 116 is thus:

$$\begin{aligned} 1+r&=1{\cdot}06\ \lambda\ 0{\cdot}025305865\\ &\qquad\times n=20\\ (1+r)^n&=3{\cdot}207135\ \lambda\ 0{\cdot}5061173\\ (1+r)^n-1&=2{\cdot}207135\ \lambda\ 0{\cdot}3438289\\ a&=120\ \lambda\ 2{\cdot}0791812\\ r&={\cdot}06\ \kappa\ 1{\cdot}2218487\\ \text{M}&=4414{\cdot}27\ \lambda\ 3{\cdot}6448588 \end{aligned}$$

And the amount required is L. 4414, 5s. 5d.

133. *Ex.* 6. The rest being the same as in the last example; if both the interest and the annuity be payable half-yearly, the amount will be determined by the second of the formulæ given in No. 127; which, in this case, will become $\frac{120}{0{\cdot}6}\left[(1{\cdot}03)^{40}-1\right]$, and the operation will be as follows:

$$1{\cdot}03 \ \lambda \ 0{\cdot}01283723$$
$$\times \ 40$$

$$(1{\cdot}03)^{40} = 3{\cdot}26204 \ \lambda \ 0{\cdot}5134892$$

$$(1{\cdot}03)^{40} - 1 = 2{\cdot}26204 \ \lambda \ 0{\cdot}3545003$$
$$120 \ \lambda \ 2{\cdot}0791812$$
$$\cdot 06 \ \kappa \ 1{\cdot}2218487$$

$$\text{M} = 4524{\cdot}08 \ \lambda \ 3{\cdot}6555302$$

So that the amount in this case, would be L. 4524, 1s. 7¼d.

## II. ON THE PROBABILITIES OF LIFE.

134. Any persons $A$, $B$, $C$, &c. being proposed, let the numbers which tables of mortality (32) adapted to them, represent to attain to their respective ages, be denoted by the symbols $a$, $b$, $c$, &c.; while lives $n$ years older than those respectively, are denoted thus: ${}^nA$, ${}^nB$, ${}^nC$, &c. and the numbers that attain to their ages, by the symbols ${}^na$, ${}^nb$, ${}^nc$, &c.; also let lives $n$ years younger than $A$, $B$, $C$, &c. be denoted thus: $A_n$, $B_n$, $C_n$, &c., while the numbers which the tables show to attain to those younger ages, are designated by the symbols $a_n$, $b_n$, $c_n$, &c.

Then, if $A$ be 21 years of age, and we use the Carlisle Table, we shall have $a = 6047$, and ${}^{14}a = 5362$, the number that attain to the age of thirty-five, or that live to be fourteen years older than $A$.

Hence the number that are represented by the table to die in $n$ years from the age of $A$, will be $a - {}^na$, that is in 14 years, $a - {}^{14}a$; and by the Carlisle Table, n 14 years from the age of 21, that is, between 21 and 35, it will be $6047 - 5362 = 685$.

135. *Problem.* To determine the probability that a proposed life $A$, will survive $n$ years.

*Solution.* $a$ being the number of lives in the table of mortality, that attain to the age of that which is proposed, conceive that number of lives to be so selected, (of which $A$ must be one,) that they may each have the same prospect with regard to longevity, as the proposed life and those in the table, or the average of those from which it was constructed; then will the number of them that survive the term be ${}^na$ (134).

So that the number of ways all equally probable, or the number of equal chances for the happening of the event in question is ${}^na$; and the whole number for its either happening or failing is $a$; therefore, according to the first principles of the doctrine of probabilities, the probability of the event happening, that is, of $A$ surviving the term, is $\frac{{}^na}{a}$.

If the age of $A$ be 14, the probability of that life surviving 7 years, or the age of 21, will, according to the Carlisle Table, be $\frac{{}^7a}{a} = \frac{6047}{6335}$, or 0·95454.

136. Since the number that die in $n$ years from the age of $A$ is $a - {}^na$ (134), it appears, in the same manner, that the probability of that life failing in $n$ years will be $\frac{a - {}^na}{a} = 1 - \frac{{}^na}{a}$ which probability, when the life, term, and table of mortality, are the same as in the last No. will be 0·04546.

137. If two lives $A$ and $B$ be proposed, since the probability of $A$ surviving $n$ years will be $\frac{{}^na}{a}$, and that of $B$ surviving the same term will be $\frac{{}^nb}{b}$; it appears from the doctrine of probabilities that $\frac{{}^na}{a} \cdot \frac{{}^nb}{b}$ or $\frac{{}^n(ab)}{ab}$ will be the measure of the probability that these lives will both survive $n$ years.

In the same manner it may be shown, that the probability of the three lives $A$, $B$, and $C$ all surviving $n$ years, will be measured by $\frac{{}^na}{a} \cdot \frac{{}^nb}{b} \cdot \frac{{}^nc}{c}$, or $\frac{{}^n(abc)}{abc}$. And, universally, that any number of lives $A$, $B$, $C$, &c. will jointly survive $n$ years, the probability is $\frac{{}^n(abc, \&c.)}{abc, \&c.}$

138. Let $\frac{{}^na}{a} = {}_na$, $\frac{{}^nb}{b} = {}_nb$, $\frac{{}^nc}{c} = {}_nc$, &c.; also let $\frac{{}^n(abc,\&c.)}{abc,\&c.} = {}_n(abc, \&c.)$; so that the probabilities of $A$, $B$, $C$, &c. surviving $n$ years may be denoted by ${}_na$, ${}_nb$, ${}_nc$, &c. respectively; and that of all those lives jointly surviving that term by ${}_n(abc,\&c.)$

Then will the probability that none of those lives will survive $n$ years, be $(1 - {}_na) \cdot (1 - {}_nb) \cdot (1 - {}_nc)$. &c.

139. But the probability that some one or more of these lives will survive $n$ years, will be just what the probability last mentioned is deficient of certainty; its measure therefore, being just what the measure of that probability is deficient of unity, will be

$$1 - (1 - {}_na) \cdot (1 - {}_nb) \cdot (1 - {}_nc) \cdot \&c.$$

140. *Corol.* 1. When there is only one life $A$, this will be ${}_na$.

141. *Corol.* 2. When there are two lives $A$ and $B$, it becomes ${}_na + {}_nb - {}_n(ab)$.

142. *Corol.* 3. When there are three lives $A$, $B$, and $C$, it becomes ${}_na + {}_nb + {}_nc - {}_n(ab) - {}_n(ac) - {}_n(bc) + {}_n(abc)$.

143. When three lives $A$, $B$, and $C$ are proposed, that at the expiration of $n$ years there will be

Algebraical View.

| living | dead | the probability is |
|---|---|---|
| $ABC$ | none | ................................ $+\ {}_n(abc)$ |
| $AB$ | $C$ | ${}_n(ab)\cdot(1-{}_nc) = {}_n(ab) - {}_n(abc)$ |
| $AC$ | $B$ | ${}_n(ac)\cdot(1-{}_nb) = {}_n(ac) - {}_n(abc)$ |
| $BC$ | $A$ | ${}_n(bc)\cdot(1-{}_na) = {}_n(bc) - {}_n(abc)$ |

And the sum of these four ${}_n(ab) + {}_n(ac) + {}_n(bc) - 2\,{}_n(abc)$, is the measure of the probability that some two at the least, out of these three lives, will survive the term.

## III. OF ANNUITIES ON LIVES.

144. Let the number of years purchase that an annuity on the life of $A$ is worth, that is, the present value of L. 1, to be received at the end of every year during the continuance of that life, be denoted by A; while the present value of an annuity on any number of joint lives $A, B, C$, &c. that is, of an annuity which is to continue during the joint existence of all the lives, but to cease with the first that fails, is denoted by ABC, &c.

Then will the value of an annuity on the joint continuance of the three lives $A, B$, and $C$, be denoted by ABC.

And on the joint continuance of the two $A$ and $B$, by AB.

145. Also let ${}^t\mathrm{A}$ and $\mathrm{A}_t$ denote the value of annuities on lives respectively older and younger than $A$, by $t$ years: While ${}^t(\mathrm{ABC}\ \&c.)$ designates the value of an annuity on the joint continuance of lives $t$ years older than $A, B, C$, &c. respectively; and $(\mathrm{ABC}\ \&c.)_t$ that of an annuity on the same number of joint lives, as many years younger than these respectively.

146. Let $\frac{1}{1+r}$, the present value of L. 1 to be received certainly at the expiration of a year, be denoted by $v$.

Then will $v^n$ be the present value of that sum certain to be received at the expiration of $n$ years.

But if its receipt at the end of that time, be dependent upon an assigned life $A$, surviving the term, its present value will, by that condition, be reduced in the ratio of certainty to the probability of $A$ surviving the term, that is, in the ratio of unity to ${}_na$, and will therefore be ${}_nav^n$.

In the same manner it appears, that if the receipt of the money at the expiration of the term be dependent upon any assigned lives, as $A, B, C$, &c. jointly surviving that period, its present value will be ${}_n(abc\ \&c.)v^n$.

147. Let us denote the sum of any series, as ${}_1(abc)v + {}_2(abc)v^2 + {}_3(abc)v^3 +$ &c. thus, $S_n(abc)v^n$, by prefixing the italic capital $S$ to the general term thereof. Then, from what has just been advanced, it will be evident, that $\mathrm{ABC}\ \&c. = S_n(abc\ \&c.)v^n$.

Algebraical View.

When there are but three lives $A, B$, and $C$; this becomes $\mathrm{ABC} = S_n(abc)v^n$.

When there are but two, $A$ and $B$, it becomes $\mathrm{AB} = S_n(ab)v^n$.

And in the same manner it appears, that for a single life $A$, $\mathrm{A} = S_nav^n$.

148. ${}_n(abc\ \&c.)v^n = \frac{{}^n(abc\ \&c.)v^n}{abc\ \&c.}$ (138), where the denominator ($abc$ &c.) is constant, while the numerator varies with the variable exponent $n$. And the most obvious method of finding the value of an annuity on any assigned single or joint lives, is to calculate the numerical value of the term ${}^n(abc\ \&c.)v^n$ for each value of $n$, and then to divide the sum of all these values by $abc$ &c.; for $\frac{S^n(abc\ \&c.)v^n}{abc\ \&c.} = S_n(abc\ \&c.)v^n = \mathrm{ABC}\ \&c.$

In calculating a table of the values of annuities on lives in that manner, for every combination of joint lives, it would be necessary to calculate the term ${}^n(abc\ \&c.)v^n$ for as many years as there might be between the age of the oldest life involved and the oldest in the table; and the same number of the terms ${}^nav^n$ for any single life of the same age.

But this labour may be greatly abridged as follows:

PROB. I.

149. Given ${}'(\mathrm{ABC}, \&c.)$, the value of an annuity on any number of joint lives, to determine ABC, &c. that of an annuity on the same number of joint lives respectively one year younger than them.

*Solution.*

If it were certain that the lives ABC, &c. would all survive one year, the proprietor of an annuity of L. 1, dependent upon their joint continuance, would, at the expiration of a year, be in possession of L. 1, (the first year's rent,) and an annuity on the same number of lives, one year older respectively than ABC, &c. therefore, in that case, the required present value of the annuity would be $v\left[1 + {}'(\mathrm{ABC}, \&c.)\right]$, (146.)

But the probability of the lives $A, B, C$, &c. jointly surviving one year, is less than certainty, in the ratio of ${}_{\prime}(abc\ \&c.)$ to unity; therefore $\mathrm{ABC}\ \&c. = {}_{\prime}(abc\ \&c.)v\left[1 + {}'(\mathrm{ABC}\ \&c.)\right]$.

150. *Corol.* 1. When there are but three lives, $A$, $B$, and $C$, this becomes $\mathrm{ABC} = {}_{\prime}(abc)v\left[1 + {}'(\mathrm{ABC})\right]$.

151. *Corol.* 2. When there are only two, $A$ and $B$, $\mathrm{AB} = {}_{\prime}(ab)v\left[1 + {}'(\mathrm{AB})\right]$.

152. *Corol.* 3. And for a single life $A$, it appears, in the same manner, that $\mathrm{A} = {}_{\prime}av\,(1 + {}'\mathrm{A})$.

153. Hence, in logarithms, we have these equations,

Algebraical View.

$\lambda\,\mathrm{A} = \lambda\,v + \lambda\,{}_{,}a + \lambda\,(1 + {}'\mathrm{A})$,

$\lambda\,\mathrm{AB} = \lambda\,v + \lambda\,{}_{,}a + \lambda\,{}_{,}b + \lambda\,[1 + {}'(\mathrm{AB})]$,

$\lambda\,\mathrm{ABC} = \lambda\,v + \lambda\,{}_{,}a + \lambda\,{}_{,}b + \lambda\,{}_{,}c + \lambda\,[1 + {}'(\mathrm{ABC})]$,

&c. &c. &c.

Upon which it may be observed, that $\lambda\,v + \lambda\,{}_{,}a$, the sum of the first two logarithms that are employed in determining A from $'$A, also enters the operation whereby AB is determined from $'$(AB). And that $\lambda\,v + \lambda\,{}_{,}a + \lambda\,{}_{,}b$, the sum of the first three logarithms that serve to determine AB from $'$(AB), is also required to determine ABC from $'$(ABC); which observation may be extended in a similar manner to any greater number of joint lives.

154. By these means it is easy to complete a table of the values of annuities on single lives of all ages; beginning with the oldest in the table, and proceeding regularly age by age to the youngest.

Also a table of the values of any number of joint lives, the lives in each succeeding combination, in any one series of operations, (according to the retrograde order of the ages in which they are computed), being one year younger respectively than those in the preceding combination.

And, if a table of single lives be computed first, then of two joint lives, next of three joint lives, and so on; the calculations made for the preceding tables will be of great use for the succeeding.

155. Having shown how to compute tables of the values of annuities on single and joint lives, we shall, in what follows, always suppose those values to be given.

156. Let the value of an annuity on the joint continuance of any number of lives, *A*, *B*, *C*, &c. that is not to be entered upon until the expiration of $t$ years be denoted by $\rceil_t$(ABC &c.)

Then, if it were certain that all the lives would survive the term, since the value of the annuity at the expiration of the term would be ${}^{t}$(ABC &c.), (145), its present value would be $v^t \cdot {}^{t}$(ABC &c.), (146).

But the measure of the probability that all the lives will survive the term is ${}_{t}(abc$ &c.), therefore

$\rceil_t$(ABC &c.) $= {}_{t}(abc$ &c.) $v^t.\ {}^{t}$ABC &c.).

In the same manner, it appears, that for a single life *A*, $\rceil_t \mathrm{A} = {}_{t}av^t.\ {}^{t}\mathrm{A}$.

157. Let an annuity for the term of $t$ years only, dependent upon the joint continuance of any number of lives, *A*, *B*, *C*, &c. be denoted by $\overline{\lceil}_{t|}$(ABC &c.); and, since this *temporary* annuity, together with an annuity on the joint continuance of the same lives *deferred* for the same term, will evidently be of the same value as an annuity to be entered upon immediately, and enjoyed during their whole joint continuance, we have $\overline{\lceil}_{t|}$(ABC &c.) + $\rceil_t$(ABC &c.) = ABC &c.; whence, $\overline{\lceil}_{t|}$(ABC &c.) = ABC &c. — $\rceil^{t}$(ABC &c.).

And for a single life *A*, $\overline{\lceil}_{t|}\mathrm{A} = \mathrm{A} - \rceil_t \mathrm{A}$.

Prob. II.

158. To determine the present value of an annuity on the survivor of the two lives *A* and *B*, (155), which we designate thus, $\overline{\mathrm{AB}}$.

*Solution.*

The probability that the survivor of these two lives will outlive the term of $n$ years, was shown in No. 141, to be ${}_{n}a + {}_{n}b - {}_{n}(ab)$; therefore, reasoning as in No. 146, it will be found, that the present value of the $n$th year's rent of this annuity is $\left[{}_{n}a + b - {}_{n}(ab)\right]v^n$, and the value of all the rents thereof will be $S\left[{}_{n}a + {}_{n}b - {}_{n}(ab)\right]v^n$, or $S_n av^n + S_n bv^n - S_n(ab)v^n$; so that $\overline{\mathrm{AB}} = \mathrm{A} + \mathrm{B} - \mathrm{AB}$ (147), agreeably to No. 48.

Prob. III.

159. To determine the present value of an annuity on the last survivor of three lives, *A*, *B*, and *C*, (155); which we denote thus, $\overline{\mathrm{ABC}}$.

*Solution.*

The present value of the *nth* year's rent is $\left[{}_{n}a + {}_{n}b + {}_{n}c - {}_{n}(ab) - {}_{n}(ac) - {}_{n}(bc) + {}_{n}(abc)\right]v^n$ (142 and 146); whence, it appears, as in the preceding number, that $\overline{\mathrm{ABC}} = \mathrm{A} + \mathrm{B} + \mathrm{C} - \mathrm{AB} - \mathrm{AC} - \mathrm{BC} + \mathrm{ABC}$, agreeably to No. 52.

Prob. IV.

160. To determine the present value of an annuity on the joint existence of the last two survivors out of three lives, *A*, *B*, *C*, (155); which we denote thus, $\overset{2}{\overline{\mathrm{ABC}}}$.

*Solution.*

The present value of the $n$th year's rent is $\left[{}_{n}(ab) + {}_{n}(ac) + {}_{n}(bc) - 2{}_{n}(abc)\right]v^n$ (143 and 146); whence, reasoning as in the two preceding numbers, we infer, that $\overset{2}{\overline{\mathrm{ABC}}} = \mathrm{AB} + \mathrm{AC} + \mathrm{BC} - 2\mathrm{ABC}$, as was demonstrated otherwise in No. 51.

161. Since the solutions of the last three problems were all obtained by showing each year's rent (as for instance the $n$th) of the annuity in question, to be of the same value with the aggregate of the rents for the same year, of all the annuities (taken with their proper signs) on the single and joint lives exhibited in the resulting formula: if any term of years be assigned, it is manifest that the value of such annuity for the term, must be the same as that of the aggregate of the annuities above mentioned, each for the same term.

Prob. V.

162. *A* and *B* being any two proposed lives now both existing, to determine the present value of an annuity receivable only while *A* survives *B*.

Algebraical View.

*Solution.*

A rent of this annuity will only be payable at the end of the $n$th year, provided that $B$ be then dead, and $A$ living; but the probability of $B$ being then dead is $1 - {}_nb$, and that of $A$ being then living ${}_na$, and these two events are independent; therefore, the probability of their both happening, or that of the rent being received, is $(1 - {}_nb)\,{}_na = {}_na - {}_n(ab)$; the present value of that rent is, therefore, $\left[{}_na - {}_n(ab)\right]v^n$; whence, it follows, that the required value of the annuity on the life of $A$ after that of $B$, is $\text{A} - \text{AB}$, agreeably to No. 60.

163. If the payment for the annuity which was the subject of the last problem, is not to be made in present money, but by a constant annual premium $p$ at the end of each year, while both the lives survive; since AB is the number of years purchase (6) that an annuity on the joint continuance of those lives is worth, the value of p will be determined by this equation, $\text{p} \cdot \text{AB} = \text{A} - \text{AB}$, whence we have $\text{p} = \frac{\text{A}}{\text{AB}} - 1$.

164. But if one premium $p$ is to be paid down now, and an equal premium at the end of each year while both the lives survive, we shall have $p \cdot (1 + \text{AB}) = \text{A} - \text{AB}$, and $p = \frac{\text{A} - \text{AB}}{1 + \text{AB}}$.

165. For numerical examples illustrative of the formulæ given from No. 158 to the present; see Nos. 66—74.

PROB. VI.

166. $A$ and $B$ are in possession of an annuity on the life of the survivor of them, which, if either of them die before a third person $C$, is then to be divided equally between $C$ and the survivor during their joint lives; to determine the value of $C$'s interest.

*Solution.*

| That at the end of the $n$th year there will be dead | living | the probability, multiplied by $C$'s proportion of the annuity in that circumstance, is |
|---|---|---|
| $A$ | $BC$ | $\frac{1}{2}(1 - {}_na) \cdot {}_n(bc) = \frac{1}{2}\left[{}_n(bc) - {}_n(abc)\right]$ |
| $B$ | $AC$ | $\frac{1}{2}(1 - {}_nb) \cdot {}_n(ac) = \frac{1}{2}\left[{}_n(ac) - {}_n(abc)\right]$ |

and the sum of these being $\frac{1}{2}\,{}_n(ac) + \frac{1}{2}\,{}_n(bc) - {}_n(abc)$, the value of $C$'s interest is $\frac{1}{2}\text{AC} + \frac{1}{2}\text{BC} - \text{ABC}$.

PROB. VII.

167. An annuity after the decease of $A$, is to be equally divided between $B$ and $C$ during their joint lives, and is then to go entirely to the last survivor for his life; it is proposed to find the value of $B$'s interest therein.

*Solution.*

Algebraical View.

| That at the end of the $n$th year there will be dead | living | The probability, multiplied by $B$'s proportion of the annuity in that circumstance, is |
|---|---|---|
| $A$ | $BC$ | ......... $+ \frac{1}{2}\,{}_n(bc) - \frac{1}{2}\,{}_n(abc)$ |
| $AC$ | $B$ | ${}_nb - {}_n(ab) - {}_n(bc) + {}_n(abc)$; and the |

sum of these being ${}_nb - {}_n(ab) - \frac{1}{2}\,{}_n(bc) + \frac{1}{2}\,{}_n(abc)$, the value of $B$'s interest is $\text{B} - \text{AB} - \frac{1}{2}\text{BC} + \frac{1}{2}\text{ABC}$.

PROB. VIII.

168. $A$, $B$, and $C$ purchase an annuity on the life of the last survivor of them, which is to be divided equally at the end of every year among such of them as may then be living; what should $A$ contribute towards the purchase of this annuity?

*Solution.*

| That at the end of $n$ years there will be dead | living | The probability, multiplied by $A$'s proportion of the annuity in that circumstance, is |
|---|---|---|
| none | $ABC$ | ............................ $+ \frac{1}{3}\,{}_n(abc)$ |
| $C$ | $AB$ | ... $+ \frac{1}{2}\,{}_n(ab)$ ......... $- \frac{1}{2}\,{}_n(abc)$ |
| $B$ | $AC$ | ............ $+ \frac{1}{2}\,{}_n(ac) - \frac{1}{2}\,{}_n(abc)$ |
| $BC$ | $A$ | ${}_na - {}_n(ab) - {}_n(ac) + {}_n(abc)$; and |

the sum of these being ${}_na - \frac{1}{2}\,{}_n(ab) - \frac{1}{2}\,{}_n(ac) + \frac{1}{3}\,{}_n(abc)$, the required value of $A$'s interest is $\text{A} - \frac{1}{2}\text{AB} - \frac{1}{2}\text{AC} + \frac{1}{3}\text{ABC}$.

PROB. IX.

169. As soon as any two of the three lives, $A$, $B$, and $C$, are extinct, $D$ or his heirs are to enter upon an annuity; which they are to enjoy during the remainder of the survivor's life; to determine the value of $D$'s interest therein.

*Solution.*

| That at the end of $n$ years there will be dead | living | The probability is |
|---|---|---|
| $AB$ | $C$ | ${}_nc - {}_n(ac) - {}_n(bc) + {}_n(abc)$ |
| $AC$ | $B$ | ${}_nb - {}_n(ab) - {}_n(bc) + {}_n(abc)$ |
| $BC$ | $A$ | ${}_na - {}_n(ab) - {}_n(ac) + {}_n(abc)$; and the |

sum of all these being ${}_na + {}_nb + {}_nc - 2\,{}_n(ab) - 2\,{}_n(ac) - 2\,{}_n(bc) + 3\,{}_n(abc)$, the value of $D$'s interest is

$$\text{A} + \text{B} + \text{C} - 2\,\text{AB} - 2\,\text{AC} - 2\,\text{BC} + 3\,\text{ABC}.$$

170. The last four may be sufficient to show the method of proceeding with any similar problems.

171. Let ${}_t\overset{m}{(abc, \&c.)}$ denote the probability that the

Algebraical View.

last $m$ survivors out of $m+\mu$ lives $A$, $B$, $C$, &c. will jointly survive the term of $t$ years. And when $\mu=0$, the expression will become $_t(abc, \text{\&c.})$ the probability that the lives will all survive the term (138).

When $m=1$ it will become $\frac{1}{_t(abc,\&c.)}$, the measure of the probability that the last survivor of them will outlive the term; which it will be better to write thus, $_t(\overline{abc, \&c.})$, retaining the vinculum, but omitting the unit over it, as in the notation of powers.

Also let $\overset{m}{\overline{\text{ABC, \&c.}}}$ denote the value of an annuity on the joint continuance of the same number of last survivors out of the same lives. Then, if $\mu$ be equal to 0, it will be ABC, &c. the value of an annuity on the joint continuance of all the lives; when $m=1$, it will be $\overline{\text{ABC, \&c.}}$ the value of an annuity on the last survivor of them. The values of annuities on the last survivor of two and of three lives, will be denoted as in Nos. 158 and 159 respectively; and that of an annuity on the joint continuance of the last two survivors out of three lives, as in No. 160.

The value of an annuity on the last $m$ survivors out of these $m+\mu$ lives, according as it is limited to the term of $t$ years, or deferred during that term, will also be denoted by $\urcorner_{t|}\overset{m}{\overline{\text{ABC, \&c.}}}$ or $\urcorner_{t}\overset{m}{\overline{\text{ABC, \&c.}}}$ (156 and 157.)

PROB. X.

172. An annuity certain for the term of $t+\nu$ years, is to be enjoyed by $P$ and his heirs during the joint existence of the last $m$ survivors out of $m+\mu$ lives, $A$, $B$, $C$, &c.; and if that joint existence fail before the expiration of $t$ years, the annuity is to go to $Q$ and his heirs, for the remainder of the term; to determine the value of $Q$'s interest in that annuity.

SOLUTION.

$Q$'s expectation may be distinguished into two parts:

1st, That of enjoying the annuity during the term of $t$ years.

2d, That of enjoying it after the expiration of that term.

The sum of the present values of the interests of $P$ and $Q$, together in the annuity for the term of $t$ years, is manifestly equal to the whole present value of the annuity certain for that term; that is, equal to $\frac{1-v^t}{r}$ (113 and 146); and the value of $P$'s interest for the term of $t$ years, is $\urcorner_{t|}\overset{m}{\overline{\text{ABC, \&c.}}}$ (171); therefore the value of $Q$'s interest for the same term is $\frac{1-v^t}{r} - \urcorner_{t|}\overset{m}{\overline{\text{ABC, \&c.}}}$

The present value of the annuity certain for $\nu$ years after $t$ years is $\frac{v^t(1-v^\nu)}{r}$ (114 and 146); and $Q$ and his heirs will receive this annuity, if the joint continuance of the last $m$ survivors above mentioned fail before the expiration of $t$ years; but the probability of their joint continuance failing in the term, is $1-\overset{m}{\overline{_t(abc, \&c.)}}$; therefore, the value of $Q$'s interest in the annuity to be received after $t$ years, is $\left[1-{}_t\left(\overset{m}{\overline{abc, \&c.}}\right)\right]\frac{v^t(1-v^\nu)}{r}$; and the whole value of $Q$'s interest, is $\frac{1}{r}\left[1-v^{\nu+t}-v^t(1-v^\nu)\cdot{}_t\left(\overset{m}{\overline{abc,\&c.}}\right)\right] - \urcorner_{t|}\overset{m}{\overline{\text{ABC, \&c.}}}$

173. *Corol.* 1. When the whole annuity certain is a perpetuity, $v^{t+\nu}=0$, and the value of $Q$'s interest is $\frac{1}{r}\left[1-{}_t\left(\overset{m}{\overline{abc, \&c.}}\right)v^t\right]-\urcorner_{t|}\overset{m}{\overline{\text{ABC, \&c.}}}$

174. *Corol.* 2. When the term $t$ is not less than the greatest joint continuance of any $m$ of the proposed lives, according to the tables of mortality adapted to them, $_t(\overset{m}{\overline{abc, \&c.}}) = 0$, and $\urcorner_{t|}\overset{m}{\overline{\text{ABC, \&c.}}} = \overset{m}{\overline{\text{ABC, \&c.}}}$; therefore, in that case, the general formula of No. 172 becomes $\frac{1-v^{\nu+t}}{r}-\overset{m}{\overline{\text{ABC, \&c.}}}$; that is, the excess of the value of an annuity certain for the whole term $\nu+t$, above that of an annuity on the whole duration of joint continuance of the last $m$ surviving lives.

175. And if, in the case proposed in the last No. the annuity certain be a perpetuity, as in No. 173, the formula will become $\frac{1}{r}-\overset{m}{\overline{\text{ABC, \&c.}}}$ the excess of the value of the perpetuity above the value of an annuity on the joint lives of the last $m$ survivors; agreeably to No. 63.

176. *Example* 1. Required the present value of the absolute reversion of an estate in fee simple, after the extinction of the last survivor of three lives, $A$, $B$, $C$, now aged 50, 55, and 60 years respectively; reckoning interest at 5 *per cent.*

The general Algebraical expression of this value has just been shown to be $\frac{1}{r}-\overline{\text{ABC}}.$

$$\text{But } \frac{1}{r}=\frac{1}{0{\cdot}5}=20{\cdot}000$$

$$\text{And } \overline{\text{ABC}}, \quad =14{\cdot}001 \ (68.)$$

Therefore 5·999 years' purchase is the value required. And if the annual produce of the estate, clear of all deductions, were L. 100, the title to the reversion would now be worth L. 599, 18s.—, agreeably to No. 76.

177. *Ex.* 2. An annuity for the term of 70 years certain (from this time), is to revert to $Q$ and his heirs at the failure of a life $A$, now 45 years of age; what is the present value of $Q$'s interest therein; reckoning the interest of money at 5 *per cent.*?

Algebraical View.

In No. 174, the Algebraical expression of the required value is shown to be $\frac{1-v^{70}}{r}$ — A.

$$\text{But } \lambda\, v = \lambda\, 1{\cdot}05 = \bar{1}{\cdot}9788107$$
$$\times\ 70$$

$$v^{70} = {\cdot}032866\ \lambda\ \bar{2}{\cdot}5167490$$
$$1-v^{70} = {\cdot}967134$$

$$\frac{1-v^{70}}{r} = \frac{{\cdot}967134}{{\cdot}05} = 19{\cdot}34268$$
$$\text{Subtract A} = 12{\cdot}64800 \text{ (Tab. VI.)}$$

remains $6{\cdot}69468$ years' purchase; so that if the annuity were L. 1000, the value of the reversion would be L. 6694, 13s. 7d.

178. *Ex.* 3. An annuity for the term of 70 years certain from this time, is to revert to *Q* and his heirs at the extinction of the survivor of two lives, *A* and *B*, now aged 40 and 50 years respectively; the interest of money being 5 *per cent.*, it is required to determine the value of *Q*'s interest in this annuity.

The algebraical expression of the value is,

$$\frac{1-v^{70}}{r} - \overline{\text{AB}} \quad (174 \text{ and } 171).$$

But by the last example $\frac{1-v^{70}}{r} = 19{\cdot}34268$

and by No. 66. $\overline{\text{AB}} = 15{\cdot}06600$

So that the required value is $4{\cdot}27668$ years' purchase; and if the annuity be L. 1,000, the present value of the reversion will be L. 4276, 13s. 7d.

## IV. OF ASSURANCES ON LIVES.

179. Let the present value of the assurance (77 and 78) of L. 1 on the life of *A* be denoted by the Old English capital $\mathfrak{A}$, and that of an assurance on the joint continuance of any number of lives *A*, *B*, *C*, &c. by $\mathfrak{ABC}$, &c. Also, let the value of an assurance on the joint continuance of any *m* of them, out of the whole number $m+\mu$ be denoted by $\overset{m}{\overline{\mathfrak{ABC}, \&c.}}$

180. And, in every case, let us designate the annual premium (83) for an assurance, by prefixing the character ⊙ to the symbol for the single premium; so that $\odot\mathfrak{A}$ may denote the annual premium for an assurance on the life of *A*; $\odot\mathfrak{ABC}$, &c. the same for an assurance on the joint continuance of all the lives, *A*, *B*, *C*, &c.; and $\odot\overset{m}{\overline{\mathfrak{ABC}, \&c.}}$ the annual premium for an assurance on the joint continuance of the last *m* survivors out of the whole number $m+\mu$ of those lives.

181. Then will ${}_{\overline{t|}}\mathfrak{A}$ and $\odot{}_{\overline{t|}}\mathfrak{A}$, ${}_{\overline{t|}}\mathfrak{ABC}$, &c. and $\odot{}_{\overline{t|}}\mathfrak{ABC}$, &c., ${}_{\overline{t|}}\overset{m}{\overline{\mathfrak{ABC}, \&c.}}$ and $\odot{}_{\overline{t|}}\overset{m}{\overline{\mathfrak{ABC}, \&c.}}$ designate the single and annual premiums for assurances on the same life or lives for the term of *t* years only.

Prob. XI.

182. To determine $\left({}_{\overline{t|}}\overset{m}{\overline{\mathfrak{ABC}, \&c.}}\right)$ the present value of an assurance on the last *m* survivors out of $m+\mu$ lives *A*, *B*, *C*, &c. for the term of *t* years only; that is, the present value of L. 1, to be received upon the joint continuance of these last *m* survivors failing in the term.

*Solution.*

By reasoning as in No. 79, it will be found, that a perpetuity, the first payment of which is to be made at the end of the year in which the last *m* survivors out of these $m+\mu$ lives may fail in the term, will be of the same present value as $\left(1+\frac{1}{r}=\right)\frac{1}{1-v}$ pounds to be received in the same event (112 and 146); but, in No. 173, the value of the reversion of such a perpetuity in that event, was shown to be

$$\frac{v}{1-v}\left[1-{}_{t}\overset{m}{\overline{(abc, \&c.)}}\,v^{t}\right] - {}_{\overline{t|}}\overset{m}{\overline{\text{ABC}, \&c.}};$$ whence it is manifest, that ${}_{\overline{t|}}\overset{m}{\overline{\mathfrak{ABC}, \&c.}}$

$$= v\left[1-{}_{t}\overset{m}{\overline{(abc, \&c.)}}\,v^{t}\right] - (1-v)\,{}_{\overline{t|}}\overset{m}{\overline{\text{ABC}, \&c.}}$$

183. Since the annual premium for this assurance must be paid at the commencement of every year in the term, while the last *m* surviving lives all subsist (83); besides the premium paid down now, one must be paid at the expiration of every year in the term except the last, provided that these last *m* survivors all outlive it; but the present value of L. 1 to be received upon their surviving that last year is ${}_{t}\overset{m}{\overline{(abc, \&c.)}}\,v^{t}$, therefore all the future premiums are now worth ${}_{\overline{t|}}\overset{m}{\overline{\text{ABC}, \&c.}} - {}_{t}\overset{m}{\overline{(abc, \&c.)}}\,v^{t}$ years' purchase, and the present value of all the premiums, or the total present value of the assurance, is

$$\odot{}_{\overline{t|}}\overset{m}{\overline{\mathfrak{ABC}, \&c.}}\left[1-{}_{t}\overset{m}{\overline{(abc, \&c.)}}\,v^{t} + {}_{\overline{t|}}\overset{m}{\overline{\text{ABC}, \&c.}}\right] =$$
$$v\left[1-{}_{t}\overset{m}{\overline{(abc, \&c.)}}\,v^{t}\right] - (1-v)\,{}_{\overline{t|}}\overset{m}{\overline{\text{ABC}, \&c.}} = 1-{}_{t}\overset{m}{\overline{(abc, \&c.)}}\,v^{t}$$
$$-(1-v)\,.\left[1-{}_{t}\overset{m}{\overline{(abc, \&c.)}}\,v^{t} + {}_{\overline{t|}}\overset{m}{\overline{\text{ABC}, \&c.}}\right],$$ whence we have

$$\odot{}_{\overline{t|}}\overset{m}{\overline{\mathfrak{ABC}, \&c.}} = \frac{1-{}_{t}\overset{m}{\overline{(abc, \&c.}}\,v^{t}}{1-{}_{t}\overset{m}{\overline{(abc, \&c.)}}\,v^{t} + {}_{\overline{t|}}\overset{m}{\overline{\text{ABC}, \&c.}}} +$$
$$v-1.$$

184. *Corol.* 1. When (*t*) the term of the assurance is not less than the greatest possible joint duration of any *m* of the proposed lives, ${}_{t}\overset{m}{\overline{(abc, \&c.)}} = 0$, ${}_{\overline{t|}}\overset{m}{\overline{\text{ABC}, \&c.}} = \overset{m}{\overline{\text{ABC}, \&c.}}$ and the general formulæ of the

Algebraical View.

two preceding numbers become respectively

$$\overset{m}{\overline{\mathfrak{ABC},\ \&c.}} = v-(1-v)\,\overset{m}{\overline{\text{ABC},\&c.}}$$

$$\text{and } \odot\,\overset{m}{\overline{\mathfrak{ABC},\ \&c.}} = \frac{1}{1+\overset{m}{\overline{\text{ABC},\&c.}}}+v-1$$

185. *Corol.* 2. In the same manner it appears, that, for a single life, $\mathfrak{A} = v-(1-v)\,\text{A}$,

$$\text{and } \odot\,\mathfrak{A} = \frac{1}{1+\text{A}}+v-1$$

186. *Corol.* 3. Also that ${}_{t\rceil}\mathfrak{A} = v\left(1-{}_{t}a v^{t}\right)-(1-v)\,{}_{t\rceil}\text{A}$

$$\text{or } {}_{t\rceil}\mathfrak{A} = v\left(1-\frac{{}^{t}a}{a}v^{t}\right)-(1-v).\left(\text{A}-\frac{{}^{t}a}{a}v^{t}.{}^{t}\text{A}\right).$$

$$\text{And } \odot\,{}_{t\rceil}\mathfrak{A} = \frac{1-{}_{t}a v^{t}}{1-{}_{t}a v^{t}+{}_{t\rceil}\text{A}}+v-1$$

$$\text{that is, } \odot\,{}_{t\rceil}\mathfrak{A} = \frac{1-\frac{{}^{t}a}{a}v^{t}}{1+\text{A}-\frac{{}^{t}a}{a}v^{t}.(1+{}^{t}\text{A})}+v-1.$$

187. *Corol.* 4. When the assurance is on the joint continuance of all the lives, the formulæ of No. 184 become respectively

$$\mathfrak{ABC},\ \&c. = v-(1-v)\ \text{ABC},\ \&c.$$

$$\text{and } \odot\ \mathfrak{ABC},\ \&c. = \frac{1}{1+\text{ABC},\ \&c.}+v-1.$$

And those of numbers 182 and 183,

$${}_{t\rceil}\mathfrak{ABC},\ \&c. = v\left(1-\frac{{}^{t}(abc,\ \&c.)}{abc,\ \&c.}v^{t}\right)-(1-v)\times\left[\text{ABC},\ \&c.-\frac{t(abc,\ \&c.)}{abc,\ \&c.}v^{t}.{}^{t}(\text{ABC},\ \&c.)\right],$$

and $\odot\,{}_{t\rceil}\mathfrak{ABC},\ \&c. =$

$$\frac{1-\frac{{}^{t}(abc,\ \&c.)}{abc,\ \&c.}v^{t}}{1+\text{ABC},\ \&c.-\frac{{}^{t}(abc,\ \&c.)}{abc,\ \&c.}v^{t}\left[1+{}^{t}(\text{ABC},\ \&c.)\right]}+v-1.$$

188. *Corol.* 5. According as the assurance is in the last survivor of two, or of three lives, the formulæ of No. 184 become respectively

$$\overline{\mathfrak{AB}} = v-(1-v)\ \overline{\text{AB}},$$

$$\text{and } \odot\ \overline{\mathfrak{AB}} = \frac{1}{1+\overline{\text{AB}}}+v-1\ ;$$

$$\text{or } \overline{\mathfrak{ABC}} = v-(1-v)\ \overline{\text{ABC}},$$

$$\text{and } \odot\ \overline{\mathfrak{ABC}} = \frac{1}{1+\overline{\text{ABC}}}+v-1.$$

And those of numbers 182 and 183 become

$${}_{t\rceil}\overline{\mathfrak{AB}} = v\left[1-{}_{t}(\overline{ab})v^{t}\right]-(1-v)\ {}_{t\rceil}\overline{\text{AB}},$$

$$\text{and } \odot\,{}_{t\rceil}\overline{\mathfrak{AB}} = \frac{1-{}_{t}(\overline{ab})v^{t}}{1-{}_{t}(\overline{ab})v^{t}+{}_{t\rceil}\overline{\text{AB}}}+v-1\ ;$$

$$\text{or } {}_{t\rceil}\overline{\mathfrak{ABC}} = v\left[1-{}_{t}(\overline{abc})v^{t}\right]-(1-v)\,{}_{t\rceil}\overline{\text{ABC}},$$

$$\text{and } \odot\,{}_{t\rceil}\overline{\mathfrak{ABC}} = \frac{1-{}_{t}(\overline{abc})v^{t}}{1-{}_{t}(abc)v^{t}+{}_{t\rceil}\overline{\text{ABC}}}+v-1$$

respectively.

Where ${}_{t}(\overline{ab}) = {}_{t}a+{}_{t}b-{}_{t}(ab)$, (141).

and ${}_{t}(\overline{abc}) = {}_{t}a+{}_{t}b+{}_{t}c-\left[{}_{t}(ab)+{}_{t}(ac)+(bc)\right]+{}_{t}(abc)$, (142).

For the values of $\overline{\text{AB}}$, $\overline{\text{ABC}}$, ${}_{t\rceil}\overline{\text{AB}}$, and ${}_{t\rceil}\overline{\text{ABC}}$, see numbers 157—159, and 161.

189. *Corol.* 6. When the assurance is on the joint continuance of the two last survivors out of the three lives *A*, *B*, *C* ; the formulæ of No. 184 become respectively

$$\overset{2}{\overline{\mathfrak{ABC}}} = v-(1-v)\,\overset{2}{\overline{\text{ABC}}},$$

$$\text{and } \odot\,\overset{2}{\overline{\mathfrak{ABC}}} = \frac{1}{1+\overset{2}{\overline{\text{ABC}}}}+v-1.$$

Those of numbers 182 and 183,

$${}_{t\rceil}\overset{2}{\overline{\mathfrak{ABC}}} = v\left[1-{}_{t}\overset{2}{\overline{(abc)}}\,v^{t}\right]-(1-v)\,{}_{t\rceil}\overset{2}{\overline{\text{ABC}}},$$

$$\text{and } \odot\,{}_{t\rceil}\overset{2}{\overline{\mathfrak{ABC}}} = \frac{1-{}_{t}\overset{2}{\overline{(abc)}}\,v^{t}}{1-{}_{t}\overset{2}{\overline{(abc)}}\,v^{t}+{}_{t\rceil}\overset{2}{\overline{\text{ABC}}}}+v-1.$$

Where ${}_{t}\left(\overset{2}{\overline{abc}}\right) = {}_{t}(ab)+{}_{t}(ac)+{}_{t}(bc)-2\,{}_{t}(abc)$, (143).

For the values of $\overset{2}{\overline{\text{ABC}}}$ and ${}_{t\rceil}\overset{2}{\overline{\text{ABC}}}$ see numbers 157, 160, and 161.

190. $v\left[1-{}_{t}\overset{m}{\overline{(abc,\ \&c.)}}\,v^{t}\right]-(1-v)\,{}_{t\rceil}\overset{m}{\overline{\text{ABC},\ \&c.}}$ the value of an assurance on any life or lives for the term of *t* years, which was given in No. 182, may also be expressed thus :

$$\left[1+{}_{t\rceil}\overset{m}{\overline{(\text{ABC},\ \&c.)}}-{}_{t}\overset{m}{\overline{(abc,\ \&c.)}}\,v^{t}\right]v-{}_{t\rceil}\overset{m}{\overline{\text{ABC},\ \&c.}}$$

And this, in words at length, is the rule given in No. 93.

191. When *t* is not less than the greatest possible joint duration of any *m* of the proposed lives, the last expression becomes $\left(1+\overset{m}{\overline{\text{ABC},\ \&c.}}\right)v-\overset{m}{\overline{\text{ABC},\ \&c.}}$ which is also equivalent to the first in No. 184 ; and, in words at length, is the rule given in No. 97, for determining the value of an assurance on any life or lives for their whole duration.

192. By substituting $\frac{1}{1+r}$ for $v$ (146) in the last expression, it becomes $\frac{1+\overset{m}{\overline{\text{ABC},\ \&c.}}}{1+r}-\overset{m}{\overline{\text{ABC},\ \&c.}}$

$$= \frac{1-r.\overset{m}{\overline{\text{ABC},\&c.}}}{1+r},\ \text{or } \frac{\frac{1}{r}-\overset{m}{\overline{\text{ABC},\&c}}}{1+\frac{1}{r}}.$$ And

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$\dfrac{\frac{1}{r}\overline{\overset{m}{-\text{ABC, \&c.}}}}{1+\frac{1}{r}} = \overline{\overset{m}{\mathfrak{ABC}}}$, &c. is the proposition enunciated in No. 81; $\frac{1}{r}$ being the value of the perpetuity (112).

193. Examples of the determination of the single premiums for assurances, and of the derivation of the annual premiums from them, have been given in numbers 82—88, also in 95 and 96; but by the algebraical formulæ given here, the annual premiums may be determined directly, without first finding the total present values of the assurances.

194. *Example* 1. Required the annual premium for an assurance on the life $A$ now 50 years of age, interest 5 *per cent.*

According to No. 185, the operation is thus,

$$\left.\begin{aligned} 1+A &= 12{\cdot}660\ \lambda \\ \frac{1}{1+A} &= {\cdot}0789890\ \kappa \end{aligned}\right\} \bar{2}{\cdot}8975663$$

adding $v = {\cdot}9523809$, and subtracting unity,

we have $\odot\, \mathfrak{A} = {\cdot}0313699$, agreeably to No. 85.

195. *Ex.* 2. What should the annual premium be for an assurance on the last survivor of three lives $A, B, C$, now aged 50, 55, and 60 years respectively, rate of interest 5 *per cent.*?

Operation by No. 188.

$$\left.\begin{aligned} (68)\ 1+\overline{\text{ABC}} &= 15{\cdot}001\ \lambda \\ \frac{1}{1+\overline{\text{ABC}}} &= {\cdot}0666622\ \kappa \end{aligned}\right\} \bar{2}{\cdot}8238798$$

$$v = {\cdot}9523809$$

$\odot\,\overline{\mathfrak{ABC}} = {\cdot}0190431$, agreeably to No. 88.

196. *Ex.* 3. Required the annual premium for an assurance for 10 years only, on a life now 45 years of age, interest 5 *per cent.*

Operation according to No. 186.

$$\begin{aligned} v^{10} &= {\cdot}613913\ \lambda\ \bar{1}{\cdot}7881068 \\ {}^{10}a &= 4073\ \lambda\ 3{\cdot}6099144 \\ a &= 4727\ \kappa\ \bar{4}{\cdot}3254144 \\ \hline {}_{10}av^{10} &= {\cdot}528976\ \lambda\ \bar{1}{\cdot}7234356 \\ 1+{}^{10}A &= 11{\cdot}347\ \lambda\ 1{\cdot}0548811 \\ \hline \text{Subtract}\quad & 6{\cdot}002\ \lambda\ 0{\cdot}7783167 \\ \text{from } 1+A &= 13{\cdot}648 \\ \hline \text{remains}\quad & 7{\cdot}646\ \kappa\ \bar{1}{\cdot}1165657 \\ 1-{}_{10}av^{10} &= {\cdot}471024\ \lambda\ \bar{1}{\cdot}6730430 \\ \hline & {\cdot}061604\ \lambda\ \bar{2}{\cdot}7896087 \\ v &= {\cdot}952381 \end{aligned}$$

$\odot\ {}_{\overline{10|}}\mathfrak{A} = .013985$, agreeably to No. 96.

What has been advanced from numbers 99 to 109, needs no algebraical illustration. (υ.)

# TABLE I.

Showing the present Value of One Pound to be received at the End of any Number of Years not exceeding 50.

(See No. 9——12 of the preceding Article.)

| Years. | 2 per Cent. | 2½ per Cent. | 3 per Cent. | 4 per Cent. | 5 per Cent. | 6 per Cent. | 7 per Cent. | 8 per Cent. | 9 per Cent. | Years |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ·980392 | ·975610 | ·970874 | ·961538 | ·952381 | ·943396 | ·934579 | ·925926 | ·917431 | 1 |
| 2 | ·961169 | ·951814 | ·942596 | ·924556 | ·907029 | ·889996 | ·873439 | ·857339 | ·841680 | 2 |
| 3 | ·942322 | ·928599 | ·915142 | ·888996 | ·863838 | ·839619 | ·816298 | ·793832 | ·772183 | 3 |
| 4 | ·923845 | ·905951 | ·888487 | ·854804 | ·822702 | ·792094 | ·762895 | ·735030 | ·708425 | 4 |
| 5 | ·905731 | ·883854 | ·862609 | ·821927 | ·783526 | ·747258 | ·712986 | ·680583 | ·649931 | 5 |
| 6 | ·887971 | ·862297 | ·837484 | ·790315 | ·746215 | ·704961 | ·666342 | ·630170 | ·596267 | 6 |
| 7 | ·870560 | ·841265 | ·813092 | ·759918 | ·710681 | ·665057 | ·622750 | ·583490 | ·547034 | 7 |
| 8 | ·853490 | ·820747 | ·789409 | ·730690 | ·676839 | ·627412 | ·582009 | ·540269 | ·501866 | 8 |
| 9 | ·836755 | ·800728 | ·766417 | ·702587 | ·644609 | ·591898 | ·543934 | ·500249 | ·460428 | 9 |
| 10 | ·820348 | ·781198 | ·744094 | ·675564 | ·613913 | ·558395 | ·508349 | ·463193 | ·422411 | 10 |
| 11 | ·804263 | ·762145 | ·722421 | ·649581 | ·584679 | ·526788 | ·475093 | ·428883 | ·387533 | 11 |
| 12 | ·788493 | ·743556 | ·701380 | ·624597 | ·556837 | ·496969 | ·444012 | ·397114 | ·355535 | 12 |
| 13 | ·773033 | ·725420 | ·680951 | ·600574 | ·530321 | ·468839 | ·414964 | ·367698 | ·326179 | 13 |
| 14 | ·757875 | ·707727 | ·661118 | ·577475 | ·505068 | ·442301 | ·387817 | ·340461 | ·299246 | 14 |
| 15 | ·743015 | ·690466 | ·641862 | ·555265 | ·481017 | ·417265 | ·362446 | ·315242 | ·274538 | 15 |
| 16 | ·728446 | ·673625 | ·623167 | ·533908 | ·458112 | ·393646 | ·338735 | ·291890 | ·251870 | 16 |
| 17 | ·714163 | ·657195 | ·605016 | ·513373 | ·436297 | ·371364 | ·316574 | ·270269 | ·231073 | 17 |
| 18 | ·700159 | ·641166 | ·587395 | ·493628 | ·415521 | ·350344 | ·295864 | ·250249 | ·211994 | 18 |
| 19 | ·686431 | ·625528 | ·570286 | ·474642 | ·395734 | ·330513 | ·276508 | ·231712 | ·194490 | 19 |
| 20 | ·672971 | ·610271 | ·553676 | ·456387 | ·376889 | ·311805 | ·258419 | ·214548 | ·178431 | 20 |
| 21 | ·659776 | ·595386 | ·537549 | ·438834 | ·358942 | ·294155 | ·241513 | ·198656 | ·163698 | 21 |
| 22 | ·646839 | ·580865 | ·521893 | ·421955 | ·341850 | ·277505 | ·225713 | ·183941 | ·150182 | 22 |
| 23 | ·634156 | ·566697 | ·506692 | ·405726 | ·325571 | ·261797 | ·210947 | ·170315 | ·137781 | 23 |
| 24 | ·621721 | ·552875 | ·491934 | ·390121 | ·310068 | ·246979 | ·197147 | ·157699 | ·126405 | 24 |
| 25 | ·609531 | ·539391 | ·477606 | ·375117 | ·295303 | ·232999 | ·184249 | ·146018 | ·115968 | 25 |
| 26 | ·597579 | ·526235 | ·463695 | ·360689 | ·281241 | ·219810 | ·172195 | ·135202 | ·106393 | 26 |
| 27 | ·585862 | ·513400 | ·450189 | ·346817 | ·267848 | ·207368 | ·160930 | ·125187 | ·097608 | 27 |
| 28 | ·574375 | ·500878 | ·437077 | ·333477 | ·255094 | ·195630 | ·150402 | ·115914 | ·089548 | 28 |
| 29 | ·563112 | ·488661 | ·424346 | ·320651 | ·242946 | ·184557 | .140563 | ·107328 | ·082155 | 29 |
| 30 | ·552071 | ·476743 | ·411987 | ·308319 | ·231377 | ·174110 | ·131367 | ·099377 | ·075371 | 30 |
| 31 | ·541246 | ·465115 | ·399987 | ·296460 | ·220359 | ·164255 | ·122773 | ·092016 | ·069148 | 31 |
| 32 | ·530633 | ·453771 | ·388337 | ·285058 | ·209866 | ·154957 | ·114741 | ·085200 | ·063438 | 32 |
| 33 | ·520229 | ·442703 | ·377026 | ·274094 | ·199873 | ·146186 | ·107235 | ·078889 | ·058200 | 33 |
| 34 | ·510028 | ·431905 | ·366045 | ·263552 | ·190355 | ·137912 | ·100219 | ·073045 | ·053395 | 34 |
| 35 | ·500028 | ·421371 | ·355383 | ·253415 | ·181290 | ·130105 | ·093663 | ·067635 | ·048986 | 35 |
| 36 | ·490223 | ·411094 | ·345032 | ·243669 | ·172657 | ·122741 | ·087535 | ·062625 | ·044941 | 36 |
| 37 | ·480611 | ·401067 | ·334983 | ·234297 | ·164436 | ·115793 | ·081809 | ·057986 | ·041231 | 37 |
| 38 | ·471187 | ·391285 | ·325226 | ·225285 | ·156605 | ·109239 | ·076457 | ·053690 | ·037826 | 38 |
| 39 | ·461948 | ·381741 | ·315754 | ·216621 | ·149148 | ·103056 | ·071455 | ·049713 | ·034703 | 39 |
| 40 | ·452890 | ·372431 | ·306557 | ·208289 | ·142046 | ·097222 | ·066780 | ·046031 | ·031838 | 40 |
| 41 | ·444010 | ·363347 | ·297628 | ·200278 | ·135282 | ·091719 | ·062412 | ·042621 | ·029209 | 41 |
| 42 | ·435304 | ·354485 | ·288959 | ·192575 | ·128840 | ·086527 | ·058329 | ·039464 | ·026797 | 42 |
| 43 | ·426769 | ·345839 | ·280543 | ·185168 | ·122704 | ·081630 | ·054513 | ·036541 | ·024584 | 43 |
| 44 | ·418401 | ·337404 | ·272372 | ·178046 | ·116861 | ·077009 | ·050946 | ·033834 | ·022555 | 44 |
| 45 | ·410197 | ·329174 | ·264439 | ·171198 | ·111297 | ·072650 | ·047613 | ·031328 | ·020692 | 45 |
| 46 | ·402154 | ·321146 | ·256737 | ·164614 | ·105997 | ·068538 | ·044499 | ·029007 | ·018984 | 46 |
| 47 | ·394268 | ·313313 | ·249259 | ·158283 | ·100949 | ·064658 | ·041587 | ·026859 | ·017416 | 47 |
| 48 | ·386538 | ·305671 | ·241999 | ·152195 | ·096142 | ·060998 | ·038867 | ·024869 | ·015978 | 48 |
| 49 | ·378958 | ·298216 | ·234950 | ·146341 | ·091564 | ·057546 | ·036324 | ·023027 | ·014659 | 49 |
| 50 | ·371528 | ·290942 | ·228107 | ·140713 | ·087204 | ·054288 | ·033948 | ·021321 | ·013449 | 50 |

## TABLE II.

Showing the present Value of an Annuity of One Pound for any Number of Years not exceeding 50.

(No. 9.——12.)

| Years. | 2 per Cent. | 2½ per Cent. | 3 per Cent. | 4 per Cent. | 5 per Cent. | 6 per Cent. | 7 per Cent. | 8 per Cent. | 9 per Cent. | Years. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ·9804 | 9·756 | ·9709 | ·9615 | ·9524 | ·9434 | ·9346 | ·9259 | ·9174 | 1 |
| 2 | 1·9416 | 1·9274 | 1·9135 | 1·8861 | 1·8594 | 1·8334 | 1·8080 | 1·7833 | 1·7591 | 2 |
| 3 | 2·8839 | 2·8560 | 2·8286 | 2·7751 | 2·7232 | 2·6730 | 2·6243 | 2·5771 | 2·5313 | 3 |
| 4 | 3·8077 | 3·7620 | 3·7171 | 3·6299 | 3·5460 | 3·4651 | 3·3872 | 3·3121 | 3·2397 | 4 |
| 5 | 4·7135 | 4·6458 | 4·5797 | 4·4518 | 4·3295 | 4·2124 | 4·1002 | 3·9927 | 3·8897 | 5 |
| 6 | 5·6014 | 5·5081 | 5·4172 | 5·2421 | 5·0757 | 4·9173 | 4·7665 | 4·6229 | 4·4859 | 6 |
| 7 | 6·4720 | 6·3494 | 6·2303 | 6·0021 | 5·7864 | 5·5824 | 5·3893 | 5·2064 | 5·0330 | 7 |
| 8 | 7·3255 | 7·1701 | 7·0197 | 6·7327 | 6·4632 | 6·2098 | 5·9713 | 5·7466 | 5·5348 | 8 |
| 9 | 8·1622 | 7·9709 | 7·7861 | 7·4353 | 7·1078 | 6·8017 | 6·5152 | 6·2469 | 5·9952 | 9 |
| 10 | 8·9826 | 8·7521 | 8·5302 | 8·1109 | 7·7217 | 7·3601 | 7·0236 | 6·7101 | 6·4177 | 10 |
| 11 | 9·7868 | 9·5142 | 9·2526 | 8·7605 | 8·3064 | 7·8869 | 7·4987 | 7·1390 | 6·8052 | 11 |
| 12 | 10·5753 | 10·2578 | 9·9540 | 9·3851 | 8·8633 | 8·3838 | 7·9427 | 7·5361 | 7·1607 | 12 |
| 13 | 11·3484 | 10·9832 | 10·6350 | 9·9856 | 9·3936 | 8·8527 | 8·3577 | 7·9038 | 7·4869 | 13 |
| 14 | 12·1062 | 11·6909 | 11·2961 | 10·5631 | 9·8986 | 9·2950 | 8·7455 | 8·2442 | 7·7862 | 14 |
| 15 | 12·8493 | 12·3814 | 11·9379 | 11·1184 | 10·3797 | 9·7122 | 9·1079 | 8·5595 | 8·0607 | 15 |
| 16 | 13·5777 | 13·0550 | 12·5611 | 11·6523 | 10·8378 | 10·1059 | 9·4466 | 8·8514 | 8·3126 | 16 |
| 17 | 14·2919 | 13·7122 | 13·1661 | 12·1657 | 11·2741 | 10·4773 | 9·7632 | 9·1216 | 8·5436 | 17 |
| 18 | 14·9920 | 14·3534 | 13·7535 | 12·6593 | 11·6896 | 10·8276 | 10·0591 | 9·3719 | 8·7556 | 18 |
| 19 | 15·6785 | 14·9789 | 14·3238 | 13·1339 | 12·0853 | 11·1581 | 10·3356 | 9·6036 | 8·9501 | 19 |
| 20 | 16·3514 | 15·5892 | 14·8775 | 13·5903 | 12·4622 | 11·4699 | 10·5940 | 9·8181 | 9·1285 | 20 |
| 21 | 17·0112 | 16·1845 | 15·4150 | 14·0292 | 12·8212 | 11·7641 | 10·8355 | 10·0168 | 9·2922 | 21 |
| 22 | 17·6580 | 16·7654 | 15·9369 | 14·4511 | 13·1630 | 12·0416 | 11·0612 | 10·2007 | 9·4424 | 22 |
| 23 | 18·2922 | 17·3321 | 16·4436 | 14·8568 | 13·4886 | 12·3034 | 11·2722 | 10·3711 | 9·5802 | 23 |
| 24 | 18·9139 | 17·8850 | 16·9355 | 15·2470 | 13·7986 | 12·5504 | 11·4693 | 10·5288 | 9·7066 | 24 |
| 25 | 19·5235 | 18·4244 | 17·4131 | 15·6221 | 14·0939 | 12·7834 | 11·6536 | 10·6748 | 9·8226 | 25 |
| 26 | 20·1210 | 18·9506 | 17·8768 | 15·9828 | 14·3752 | 13·0032 | 11·8258 | 10·8100 | 9·9290 | 26 |
| 27 | 20·7069 | 19·4640 | 18·3270 | 16·3296 | 14·6430 | 13·2105 | 11·9867 | 10·9352 | 10·0266 | 27 |
| 28 | 21·2813 | 19·9649 | 18·7641 | 16·6631 | 14·8981 | 13·4062 | 12·1371 | 11·0511 | 10·1161 | 28 |
| 29 | 21·8444 | 20·4535 | 19·1885 | 16·9837 | 15·1411 | 13·5907 | 12·2777 | 11·1584 | 10·1983 | 29 |
| 30 | 22·3965 | 20·9303 | 19·6004 | 17·2920 | 15·3725 | 13·7648 | 12·4090 | 11·2578 | 10·2737 | 30 |
| 31 | 22·9377 | 21·3954 | 20·0004 | 17·5885 | 15·5928 | 13·9291 | 12·5318 | 11·3498 | 10·3428 | 31 |
| 32 | 23·4683 | 21·8492 | 20·3888 | 17·8736 | 15·8027 | 14·0840 | 12·6466 | 11·4350 | 10·4062 | 32 |
| 33 | 23·9886 | 22·2919 | 20·7658 | 18·1476 | 16·0025 | 14·2302 | 12·7538 | 11·5139 | 10·4644 | 33 |
| 34 | 24·4986 | 22·7238 | 21·1318 | 18·4112 | 16·1929 | 14·3681 | 12·8540 | 11·5869 | 10·5178 | 34 |
| 35 | 24·9986 | 23·1452 | 21·4872 | 18·6646 | 16·3742 | 14·4982 | 12·9477 | 11·6546 | 10·5668 | 35 |
| 36 | 25·4888 | 23·5563 | 21·8323 | 18·9083 | 16·5469 | 14·6210 | 13·0352 | 11·7172 | 10·6118 | 36 |
| 37 | 25·9695 | 23·9573 | 22·1672 | 19·1426 | 16·7113 | 14·7368 | 13·1170 | 11·7752 | 10·6530 | 37 |
| 38 | 26·4406 | 24·3486 | 22·4925 | 19·3679 | 16·8679 | 14·8460 | 13·1935 | 11·8289 | 10·6908 | 38 |
| 39 | 26·9026 | 24·7303 | 22·8082 | 19·5845 | 17·0170 | 14·9491 | 13·2649 | 11·8786 | 10·7255 | 39 |
| 40 | 27·3555 | 25·1028 | 23·1148 | 19·7928 | 17·1591 | 15·0463 | 13·3317 | 11·9246 | 10·7574 | 40 |
| 41 | 27·7995 | 25·4661 | 23·4124 | 19·9931 | 17·2944 | 15·1380 | 13·3941 | 11·9672 | 10·7866 | 41 |
| 42 | 28·2348 | 25·8206 | 23·7014 | 20·1856 | 17·4232 | 15·2245 | 13·4524 | 12·0067 | 10·8134 | 42 |
| 43 | 28·6616 | 26·1664 | 23·9819 | 20·3708 | 17·5459 | 15·3062 | 13·5070 | 12·0432 | 10·8380 | 43 |
| 44 | 29·0800 | 26·5038 | 24·2543 | 20·5488 | 17·6628 | 15·3832 | 13·5579 | 12·0771 | 10·8605 | 44 |
| 45 | 29·4902 | 26·8330 | 24·5187 | 20·7200 | 17·7741 | 15·4558 | 13·6055 | 12·1084 | 10·8812 | 45 |
| 46 | 29·8923 | 27·1542 | 24·7754 | 20·8847 | 17·8801 | 15·5244 | 13·6500 | 12·1374 | 10·9002 | 46 |
| 47 | 30·2866 | 27·4675 | 25·0247 | 21·0429 | 17·9810 | 15·5890 | 13·6916 | 12·1643 | 10·9176 | 47 |
| 48 | 30·6731 | 27·7732 | 25·2667 | 21·1951 | 18·0772 | 15·6500 | 13·7305 | 12·1891 | 10·9336 | 48 |
| 49 | 31·0521 | 28·0714 | 25·5017 | 21·3415 | 18·1687 | 15·7076 | 13·7668 | 12·2122 | 10·9482 | 49 |
| 50 | 31·4236 | 28·3623 | 25·7298 | 21·4822 | 18·2559 | 15·7619 | 13·8007 | 12·2335 | 10·9617 | 50 |
| Perp. | 50·0000 | 40·0000 | 33.3333 | 25·0000 | 20·0000 | 16·6667 | 14·2857 | 12·5000 | 11·1111 | Perp. |

## TABLE III.

Showing the Sum to which One Pound will increase when improved at Compound Interest during any Number of Years not exceeding *50*.

(No. 9——12.)

| Years | 2 per Cent. | 2½ per Cent. | 3 per Cent. | 4 per Cent. | 5 per Cent. | 6 per Cent. | 7 per Cent. | 8 per Cent. | Years |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1·02000 | 1·02500 | 1·030000 | 1·040000 | 1·050000 | 1·060000 | 1·070000 | 1·080000 | 1 |
| 2 | 1·04040 | 1·05063 | 1·060900 | 1·081600 | 1·102500 | 1·123600 | 1·144900 | 1·166400 | 2 |
| 3 | 1·06121 | 1·07689 | 1·092727 | 1·124864 | 1·157625 | 1·191016 | 1·225043 | 1·259712 | 3 |
| 4 | 1·08243 | 1·10381 | 1·125509 | 1·169859 | 1·215506 | 1·262477 | 1·310796 | 1·360489 | 4 |
| 5 | 1·10408 | 1·13141 | 1·159274 | 1·216653 | 1·276282 | 1·338226 | 1·402552 | 1·469328 | 5 |
| 6 | 1·12616 | 1·15969 | 1·194052 | 1·265319 | 1·340096 | 1·418519 | 1·500730 | 1·586874 | 6 |
| 7 | 1·14869 | 1·18869 | 1·229874 | 1·315932 | 1·407100 | 1·503630 | 1·605781 | 1·713824 | 7 |
| 8 | 1·17166 | 1·21840 | 1·266770 | 1·368569 | 1·477455 | 1·593848 | 1·718186 | 1·850930 | 8 |
| 9 | 1·19509 | 1·24886 | 1·304773 | 1·423312 | 1·551328 | 1·689479 | 1·838459 | 1·999005 | 9 |
| 10 | 1·21899 | 1·28008 | 1·343916 | 1·480244 | 1·628895 | 1·790848 | 1·967151 | 2·158925 | 10 |
| 11 | 1·24337 | 1·31209 | 1·384234 | 1·539454 | 1·710339 | 1·898299 | 2·104852 | 2·331639 | 11 |
| 12 | 1·26824 | 1·34489 | 1·425761 | 1·601032 | 1·795856 | 2·012196 | 2·252192 | 2·518170 | 12 |
| 13 | 1·29361 | 1·37851 | 1·468534 | 1·665074 | 1·885649 | 2·132928 | 2·409845 | 2·719624 | 13 |
| 14 | 1·31948 | 1·41297 | 1·512590 | 1·731676 | 1·979932 | 2·260904 | 2·578534 | 2·937194 | 14 |
| 15 | 1·34587 | 1·44830 | 1·557967 | 1·800944 | 2·078928 | 2·396558 | 2·759032 | 3·172169 | 15 |
| 16 | 1·37279 | 1·48451 | 1·604706 | 1·872981 | 2·182875 | 2·540352 | 2·952164 | 3·425943 | 16 |
| 17 | 1·40024 | 1·52162 | 1·652848 | 1·947901 | 2·292018 | 2·692773 | 3·158815 | 3·700018 | 17 |
| 18 | 1·42825 | 1·55966 | 1·702433 | 2·025817 | 2·406619 | 2·854339 | 3·379932 | 3·996020 | 18 |
| 19 | 1·45681 | 1·59865 | 1·753506 | 2·106849 | 2·526950 | 3·025600 | 3·616528 | 4·315701 | 19 |
| 20 | 1·48595 | 1·63862 | 1·806111 | 2·191123 | 2·653298 | 3·207135 | 3·869684 | 4·660957 | 20 |
| 21 | 1·51567 | 1·67958 | 1·860295 | 2·278768 | 2·785963 | 3·399564 | 4·140562 | 5·033834 | 21 |
| 22 | 1·54598 | 1·72157 | 1·916103 | 2·369919 | 2·925261 | 3·603537 | 4·430402 | 5·436540 | 22 |
| 23 | 1·57690 | 1·76461 | 1·973587 | 2·464716 | 3·071524 | 3·819750 | 4·740530 | 5·871464 | 23 |
| 24 | 1·60844 | 1·80873 | 2·032794 | 2·563304 | 3·225100 | 4·048935 | 5·072367 | 6·341181 | 24 |
| 25 | 1·64061 | 1·85394 | 2·093778 | 2·665836 | 3·386355 | 4·291871 | 5·427433 | 6·848475 | 25 |
| 26 | 1·67342 | 1·90029 | 2·156591 | 2·772470 | 3·555673 | 4·549383 | 5·807353 | 7·396353 | 26 |
| 27 | 1·70689 | 1·94780 | 2·221289 | 2·883369 | 3·733456 | 4·822346 | 6·213868 | 7·988061 | 27 |
| 28 | 1·74102 | 1·99650 | 2·287928 | 2·998703 | 3·920129 | 5·111687 | 6·648838 | 8·627106 | 28 |
| 29 | 1·77584 | 2·04641 | 2·356566 | 3·118651 | 4·116136 | 5·418388 | 7·114257 | 9·317275 | 29 |
| 30 | 1·81136 | 2·09757 | 2·427262 | 3·243398 | 4·321942 | 5·743491 | 7·612255 | 10·062657 | 30 |
| 31 | 1·84759 | 2·15001 | 2·500080 | 3·373133 | 4·538039 | 6·088101 | 8·145113 | 10·867669 | 31 |
| 32 | 1·88454 | 2·20376 | 2·575083 | 3·508059 | 4·764941 | 6·453387 | 8·715271 | 11·737083 | 32 |
| 33 | 1·92223 | 2·25885 | 2·652335 | 3·648381 | 5·003189 | 6·840590 | 9·325340 | 12·676050 | 33 |
| 34 | 1·96068 | 2·31532 | 2·731905 | 3·794316 | 5·253348 | 7·251025 | 9·978114 | 13·690134 | 34 |
| 35 | 1·99989 | 2·37321 | 2·813862 | 3·946089 | 5·516015 | 7·686087 | 10·676581 | 14·785344 | 35 |
| 36 | 2·03989 | 2·43254 | 2·898278 | 4·103933 | 5·791816 | 8·147252 | 11·423942 | 15·968172 | 36 |
| 37 | 2·08069 | 2·49335 | 2·985227 | 4·268090 | 6·081407 | 8·636087 | 12·223618 | 17·245626 | 37 |
| 38 | 2·12230 | 2·55568 | 3·074783 | 4·438813 | 6·385477 | 9·154252 | 13·079271 | 18·625276 | 38 |
| 39 | 2·16474 | 2·61957 | 3·167027 | 4·616366 | 6·704751 | 9·703507 | 13·994820 | 20·115298 | 39 |
| 40 | 2·20804 | 2·68506 | 3·262038 | 4·801021 | 7·039989 | 10·285718 | 14·974458 | 21·724522 | 40 |
| 41 | 2·25220 | 2·75219 | 3·359899 | 4·993061 | 7·391988 | 10·902861 | 16·022670 | 23·462483 | 41 |
| 42 | 2·29724 | 2·82100 | 3·460696 | 5·192784 | 7·761588 | 11·557033 | 17·144257 | 25·339482 | 42 |
| 43 | 2·34319 | 2·89152 | 3·564517 | 5·400495 | 8·149667 | 12·250455 | 18·344355 | 27·366640 | 43 |
| 44 | 2·39005 | 2·96381 | 3·671452 | 5·616515 | 8·557150 | 12·985482 | 19·628460 | 29·555972 | 44 |
| 45 | 2·43785 | 3·03790 | 3·781596 | 5·841176 | 8·985008 | 13·764611 | 21·002452 | 31·920449 | 45 |
| 46 | 2·48661 | 3·11385 | 3·895044 | 6·074823 | 9·434258 | 14·590487 | 22·472623 | 34·474085 | 46 |
| 47 | 2·53634 | 3·19170 | 4·011895 | 6·317816 | 9·905971 | 15·465917 | 24·045707 | 37·232012 | 47 |
| 48 | 2·58707 | 3·27149 | 4·132252 | 6·570528 | 10·401270 | 16·393872 | 25·728907 | 40·210573 | 48 |
| 49 | 2·63881 | 3·35328 | 4·256219 | 6·833349 | 10·921333 | 17·377504 | 27·529930 | 43·427419 | 49 |
| 50 | 2·69159 | 3·43711 | 4·383906 | 7·106683 | 11·467400 | 18·420154 | 29·457025 | 46·901613 | 50 |

## TABLE IV.

Showing the Amount to which One Pound *per Annum* will increase at Compound Interest in any Number of Years not exceeding 50.

(No. 9——12.)

| Years | 2 per Cent. | 2½ per Cent. | 3 per Cent. | 4 per Cent. | 5 per Cent. | 6 per Cent. | 7 per Cent. | Years |
|---|---|---|---|---|---|---|---|---|
| 1 | 1·0000 | 1·0000 | 1·000000 | 1·000000 | 1·000000 | 1·000000 | 1·000000 | 1 |
| 2 | 2·0200 | 2·0250 | 2·030000 | 2·040000 | 2·050000 | 2·060000 | 2·070000 | 2 |
| 3 | 3·0604 | 3·0756 | 3·090900 | 3·121600 | 3·152500 | 3·183600 | 3·214900 | 3 |
| 4 | 4·1216 | 4·1525 | 4·183627 | 4·246464 | 4·310125 | 4·374616 | 4·439943 | 4 |
| 5 | 5·2040 | 5·2563 | 5·309136 | 5·416323 | 5·525631 | 5·637093 | 5·750739 | 5 |
| 6 | 6·3081 | 6·3877 | 6·468410 | 6·632975 | 6·801913 | 6·975319 | 7·153291 | 6 |
| 7 | 7·4343 | 7·5474 | 7·662462 | 7·898294 | 8·142008 | 8·393838 | 8·654021 | 7 |
| 8 | 8·5830 | 8·7361 | 8·892336 | 9·214226 | 9·549109 | 9·897468 | 10·259803 | 8 |
| 9 | 9·7546 | 9·9545 | 10·159106 | 10·582795 | 11·026564 | 11·491316 | 11·977989 | 9 |
| 10 | 10·9497 | 11·2034 | 11·463879 | 12·006107 | 12·577893 | 13·180795 | 13·816448 | 10 |
| 11 | 12·1687 | 12·4835 | 12·807796 | 13·486351 | 14·206787 | 14·971643 | 15·783599 | 11 |
| 12 | 13·4121 | 13·7956 | 14·192030 | 15·025805 | 15·917127 | 16·869941 | 17·888451 | 12 |
| 13 | 14·6803 | 15·1404 | 15·617790 | 16·626838 | 17·712983 | 18·882138 | 20·140643 | 13 |
| 14 | 15·9739 | 16·5190 | 17·086324 | 18·291911 | 19·598632 | 21·015066 | 22·550488 | 14 |
| 15 | 17·2934 | 17·9319 | 18·598914 | 20·023588 | 21·578564 | 23·275970 | 25·129022 | 15 |
| 16 | 18·6393 | 19·3802 | 20·156881 | 21·824531 | 23·657492 | 25·672528 | 27·888054 | 16 |
| 17 | 20·0121 | 20·8647 | 21·761588 | 23·697512 | 25·840366 | 28·212880 | 30·840217 | 17 |
| 18 | 21·4123 | 22·3863 | 23·414435 | 25·645413 | 28·132385 | 30·905653 | 33·999033 | 18 |
| 19 | 22·8406 | 23·9460 | 25·116868 | 27·671229 | 30·539004 | 33·759992 | 37·378965 | 19 |
| 20 | 24·2974 | 25·5447 | 26·870374 | 29·778079 | 33·065954 | 36·785591 | 40·995492 | 20 |
| 21 | 25·7833 | 27·1833 | 28·676486 | 31·969202 | 35·719252 | 39·992727 | 44·865177 | 21 |
| 22 | 27·2990 | 28·8629 | 30·536780 | 34·247970 | 38·505214 | 43·392290 | 49·005739 | 22 |
| 23 | 28·8450 | 30·5844 | 32·452884 | 36·617889 | 41·430475 | 46·995828 | 53·436141 | 23 |
| 24 | 30·4219 | 32·3490 | 34·426470 | 39·082604 | 44·501999 | 50·815577 | 58·176671 | 24 |
| 25 | 32·0303 | 34·1578 | 36·459264 | 41·645908 | 47·727099 | 54·864512 | 63·249038 | 25 |
| 26 | 33·6709 | 36·0117 | 38·553042 | 44·311745 | 51·113454 | 59·156383 | 68·676470 | 26 |
| 27 | 35·3443 | 37·9120 | 40·709634 | 47·084214 | 54·669126 | 63·705766 | 74·483823 | 27 |
| 28 | 37·0512 | 39·8598 | 42·930923 | 49·967583 | 58·402583 | 68·528112 | 80·697691 | 28 |
| 29 | 38·7922 | 41·8563 | 45·218850 | 52·966286 | 62·322712 | 73·639798 | 87·346529 | 29 |
| 30 | 40·5681 | 43·9027 | 47·575416 | 56·084938 | 66·438848 | 79·058186 | 94·460786 | 30 |
| 31 | 42·3794 | 46·0003 | 50·002678 | 59·328335 | 70·760790 | 84·801677 | 102·073041 | 31 |
| 32 | 44·2270 | 48·1503 | 52·502759 | 62·701469 | 75·298829 | 90·889778 | 110·218154 | 32 |
| 33 | 46·1116 | 50·3540 | 55·077841 | 66·209527 | 80·063771 | 97·343165 | 118·933425 | 33 |
| 34 | 48·0338 | 52·6129 | 57·730177 | 69·857909 | 85·066959 | 104·183755 | 128·258765 | 34 |
| 35 | 49·9945 | 54·9282 | 60·462082 | 73·652225 | 90·320307 | 111·434780 | 138·236878 | 35 |
| 36 | 51·9944 | 57·3014 | 63·275944 | 77·598314 | 95·836323 | 119·120867 | 148·913460 | 36 |
| 37 | 54·0343 | 59·7339 | 66·174223 | 81·702246 | 101·628139 | 127·268119 | 160·337402 | 37 |
| 38 | 56·1149 | 62·2273 | 69·159449 | 85·970336 | 107·709546 | 135·904206 | 172·561020 | 38 |
| 39 | 58·2372 | 64·7830 | 72·234233 | 90·409150 | 114·095023 | 145·058458 | 185·640292 | 39 |
| 40 | 60·4020 | 67·4026 | 75·401260 | 95·025516 | 120·799774 | 154·761966 | 199·635112 | 40 |
| 41 | 62·6100 | 70·0876 | 78·663298 | 99·826536 | 127·839763 | 165·047684 | 214·609570 | 41 |
| 42 | 64·8622 | 72·8398 | 82·023196 | 104·819598 | 135·231751 | 175·950545 | 230·632240 | 42 |
| 43 | 67·1595 | 75·6608 | 85·483892 | 110·012382 | 142·993339 | 187·507577 | 247·776496 | 43 |
| 44 | 69·5027 | 78·5523 | 89·048409 | 115·412877 | 151·143006 | 199·758032 | 266·120851 | 44 |
| 45 | 71·8927 | 81·5161 | 92·719861 | 121·029392 | 159·700156 | 212·743514 | 285·749311 | 45 |
| 46 | 74·3306 | 84·5540 | 96·501457 | 126·870568 | 168·685164 | 226·508125 | 306·751763 | 46 |
| 47 | 76·8172 | 87·6679 | 100·396501 | 132·945390 | 178·119422 | 241·098612 | 329·224386 | 47 |
| 48 | 79·3535 | 90·8596 | 104·408396 | 139·263206 | 188·025393 | 256·564529 | 353·270093 | 48 |
| 49 | 81·9406 | 94·1311 | 108·540648 | 145·833734 | 198·426663 | 272·958401 | 378·999000 | 49 |
| 50 | 84·5794 | 97·4843 | 112·796867 | 152·667084 | 209·347996 | 290·335905 | 406·528929 | 50 |

## TABLE V.

Exhibiting the Law of Mortality at *Carlisle*. (No. 32.)

| Age. | Number who complete that Age. | Number who die in the next interval. | Age. | Number who complete that Year. | Number who die in their next Year. | Age. | Number who complete that Year. | Number who die in their next Year. |
|---|---|---|---|---|---|---|---|---|
| 0 | 10,000 | 533 | 32 | 5528 | 56 | 69 | 2525 | 124 |
| 1 Month | 9467 | 154 | 33 | 5472 | 55 | 70 | 2401 | 124 |
| 2 Months | 9313 | 87 | 34 | 5417 | 55 | 71 | 2277 | 134 |
| 3 | 9226 | 256 | 35 | 5362 | 55 | 72 | 2143 | 146 |
| 6 | 8970 | 255 | 36 | 5307 | 56 | 73 | 1997 | 156 |
| 9 | 8715 | 254 | 37 | 5251 | 57 | 74 | 1841 | 166 |
| 1 Year | 8461 | 682 | 38 | 5194 | 58 | 75 | 1675 | 160 |
| 2 Years | 7779 | 505 | 39 | 5136 | 61 | 76 | 1515 | 156 |
| 3 | 7274 | 276 | 40 | 5075 | 66 | 77 | 1359 | 146 |
| 4 | 6998 | 201 | 41 | 5009 | 69 | 78 | 1213 | 132 |
| 5 | 6797 | 121 | 42 | 4940 | 71 | 79 | 1081 | 128 |
| 6 | 6676 | 82 | 43 | 4869 | 71 | 80 | 953 | 116 |
| 7 | 6594 | 58 | 44 | 4798 | 71 | 81 | 837 | 112 |
| 8 | 6536 | 43 | 45 | 4727 | 70 | 82 | 725 | 102 |
| 9 | 6493 | 33 | 46 | 4657 | 69 | 83 | 623 | 94 |
| 10 | 6460 | 29 | 47 | 4588 | 67 | 84 | 529 | 84 |
| 11 | 6431 | 31 | 48 | 4521 | 63 | 85 | 445 | 78 |
| 12 | 6400 | 32 | 49 | 4458 | 61 | 86 | 367 | 71 |
| 13 | 6368 | 33 | 50 | 4397 | 59 | 87 | 296 | 64 |
| 14 | 6335 | 35 | 51 | 4338 | 62 | 88 | 232 | 51 |
| 15 | 6300 | 39 | 52 | 4276 | 65 | 89 | 181 | 39 |
| 16 | 6261 | 42 | 53 | 4211 | 68 | 90 | 142 | 37 |
| 17 | 6219 | 43 | 54 | 4143 | 70 | 91 | 105 | 30 |
| 18 | 6176 | 43 | 55 | 4073 | 73 | 92 | 75 | 21 |
| 19 | 6133 | 43 | 56 | 4000 | 76 | 93 | 54 | 14 |
| 20 | 6090 | 43 | 57 | 3924 | 82 | 94 | 40 | 10 |
| 21 | 6047 | 42 | 58 | 3842 | 93 | 95 | 30 | 7 |
| 22 | 6005 | 42 | 59 | 3749 | 106 | 96 | 23 | 5 |
| 23 | 5963 | 42 | 60 | 3643 | 122 | 97 | 18 | 4 |
| 24 | 5921 | 42 | 61 | 3521 | 126 | 98 | 14 | 3 |
| 25 | 5879 | 43 | 62 | 3395 | 127 | 99 | 11 | 2 |
| 26 | 5836 | 43 | 63 | 3268 | 125 | 100 | 9 | 2 |
| 27 | 5793 | 45 | 64 | 3143 | 125 | 101 | 7 | 2 |
| 28 | 5748 | 50 | 65 | 3018 | 124 | 102 | 5 | 2 |
| 29 | 5698 | 56 | 66 | 2894 | 123 | 103 | 3 | 2 |
| 30 | 5642 | 57 | 67 | 2771 | 123 | 104 | 1 | 1 |
| 31 | 5585 | 57 | 68 | 2648 | 123 | | | |

## TABLE VI.

Showing the Value of an Annuity on a Single Life at every Age, according to the Carlisle Table of Mortality, when the rate of Interest is *Five per Cent.* (No. 65.)

| Age. | Value. | Age. | Value | Age. | Value | Age. | Value. | Age. | Value. | Age. | Value. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 12·083 | 18 | 15·987 | 35 | 14·127 | 52 | 11·154 | 69 | 6·643 | 86 | 2·830 |
| 1 | 13·995 | 19 | 15·904 | 36 | 13·987 | 53 | 10·892 | 70 | 6·336 | 87 | 2·685 |
| 2 | 14·983 | 20 | 15·817 | 37 | 13·843 | 54 | 10·624 | 71 | 6·015 | 88 | 2·597 |
| 3 | 15·824 | 21 | 15·726 | 38 | 13·695 | 55 | 10·347 | 72 | 5·711 | 89 | 2·495 |
| 4 | 16·271 | 22 | 15·628 | 39 | 13·542 | 56 | 10.063 | 73 | 5·435 | 90 | 2·339 |
| 5 | 16·590 | 23 | 15·525 | 40 | 13·390 | 57 | 9·771 | 74 | 5·190 | 91 | 2·321 |
| 6 | 16·735 | 24 | 15·417 | 41 | 13·245 | 58 | 9·478 | 75 | 4·989 | 92 | 2·412 |
| 7 | 16·790 | 25 | 15·303 | 42 | 13·101 | 59 | 9·199 | 76 | 4·792 | 93 | 2·518 |
| 8 | 16·786 | 26 | 15·187 | 43 | 12·957 | 60 | 8·940 | 77 | 4·609 | 94 | 2·569 |
| 9 | 16·742 | 27 | 15·065 | 44 | 12·806 | 61 | 8·712 | 78 | 4·422 | 95 | 2·596 |
| 10 | 16·669 | 28 | 14·942 | 45 | 12·648 | 62 | 8·487 | 79 | 4·210 | 96 | 2·555 |
| 11 | 16·581 | 29 | 14·827 | 46 | 12·480 | 63 | 8·258 | 80 | 4·015 | 97 | 2·428 |
| 12 | 16·494 | 30 | 14·723 | 47 | 12·301 | 64 | 8·016 | 81 | 3·799 | 98 | 2·278 |
| 13 | 16·406 | 31 | 14·617 | 48 | 12·107 | 65 | 7·765 | 82 | 3·606 | 99 | 2·045 |
| 14 | 16·316 | 32 | 14·506 | 49 | 11·892 | 66 | 7·503 | 83 | 3·406 | 100 | 1·624 |
| 15 | 16·227 | 33 | 14·387 | 50 | 11·660 | 67 | 7·227 | 84 | 3·211 | 101 | 1·192 |
| 16 | 16·144 | 34 | 14·260 | 51 | 11·410 | 68 | 6·941 | 85 | 3·009 | 102 | 0·753 |
| 17 | 16·066 | | | | | | | | | 103 | 0·317 |

## TABLE VII.

Showing the Value of an Annuity on the Joint Continuance of Two Lives, according to the Carlisle Table of Mortality, when the difference of their Ages is Five Years, and the rate of Interest *Five per Cent.* (No. 65.)

| Ages. | Value. | Ages. | Value. | Ages. | Value. | Ages. | Value. | Ages. | Value. |
|---|---|---|---|---|---|---|---|---|---|
| 0 & 5 | 10·551 | 20 & 25 | 13·398 | 40 & 45 | 10·598 | 59 & 64 | 6·127 | 79 & 84 | 2·045 |
| 1 & 6 | 12·331 | 21 & 26 | 13·272 | 41 & 46 | 10·444 | 60 & 65 | 5·895 | 80 & 85 | 1·895 |
| 2 & 7 | 13·258 | 22 & 27 | 13·137 | 42 & 47 | 10·287 | 61 & 66 | 5·678 | 81 & 86 | 1·747 |
| 3 & 8 | 14·019 | 23 & 28 | 13·000 | 43 & 48 | 10·121 | 62 & 67 | 5·458 | 82 & 87 | 1·626 |
| 4 & 9 | 14·402 | 24 & 29 | 12·867 | 44 & 49 | 9·937 | 63 & 68 | 5·230 | 83 & 88 | 1·535 |
| 5 & 10 | 14·649 | 25 & 30 | 12·742 | 45 & 50 | 9·737 | 64 & 69 | 4·988 | 84 & 89 | 1·433 |
| 6 & 11 | 14·731 | 26 & 31 | 12·615 | 46 & 51 | 9·519 | 65 & 70 | 4·737 | 85 & 90 | 1·279 |
| 7 & 12 | 14·736 | 27 & 32 | 12·482 | 47 & 52 | 9·292 | 66 & 71 | 4·469 | 86 & 91 | 1·203 |
| 8 & 13 | 14·689 | 28 & 33 | 12·344 | 48 & 53 | 9·054 | 67 & 72 | 4·207 | 87 & 92 | 1·192 |
| 9 & 14 | 14·606 | 29 & 34 | 12·208 | 49 & 54 | 8·799 | 68 & 73 | 3·961 | 88 & 93 | 1·219 |
| 10 & 15 | 14·500 | 30 & 35 | 12·078 | 50 & 55 | 8·528 | 69 & 74 | 3·731 | 89 & 94 | 1·214 |
| 11 & 16 | 14·389 | 31 & 36 | 11·944 | 51 & 56 | 8·242 | 70 & 75 | 3.528 | 90 & 95 | 1·167 |
| 12 & 17 | 14·284 | 32 & 37 | 11·806 | 52 & 57 | 7·950 | 71 & 76 | 3·319 | 91 & 96 | 1·161 |
| 13 & 18 | 14·178 | 33 & 38 | 11·661 | 53 & 58 | 7·657 | 72 & 77 | 3·127 | 92 & 97 | 1·181 |
| 14 & 19 | 14·069 | 34 & 39 | 11·508 | 54 & 59 | 7·375 | 73 & 78 | 2·948 | 93 & 98 | 1·215 |
| 15 & 20 | 13·959 | 35 & 40 | 11·354 | 55 & 60 | 7·106 | 74 & 79 | 2·767 | 94 & 99 | 1·191 |
| 16 & 21 | 13·853 | 36 & 41 | 11·204 | 56 & 61 | 6·860 | 75 & 80 | 2·623 | 95 & 100 | 1·038 |
| 17 & 22 | 13·746 | 37 & 42 | 11·056 | 57 & 62 | 6·615 | 76 & 81 | 2·467 | 96 & 101 | 0·828 |
| 18 & 23 | 13·636 | 38 & 43 | 10·907 | 58 & 63 | 6·370 | 77 & 82 | 2·333 | 97 & 102 | 0·555 |
| 19 & 24 | 13·520 | 39 & 44 | 10·753 | | | 78 & 83 | 2·194 | 98 & 103 | 0·249 |

## TABLE VIII.

Showing the Value of an Annuity on the Joint Continuance of Two Lives, according to the Carlisle Table of Mortality, when the difference of their Ages is Ten Years, and the rate of Interest *Five per Cent.* (No. 65.)

| Ages. | Value. | Ages. | Value. | Ages. | Value. | Ages. | Value. | Ages. | Value. |
|---|---|---|---|---|---|---|---|---|---|
| 0 & 10 | 10·649 | 19 & 29 | 13·117 | 38 & 48 | 10·396 | 56 & 66 | 6·156 | 75 & 85 | 2·100 |
| 1 & 11 | 12·275 | 20 & 30 | 13·008 | 39 & 49 | 10·195 | 57 & 67 | 5·881 | 76 & 86 | 1·956 |
| 2 & 12 | 13·087 | 21 & 31 | 12·896 | 40 & 50 | 9·984 | 58 & 68 | 5·600 | 77 & 87 | 1·838 |
| 3 & 13 | 13·769 | 22 & 32 | 12·776 | 41 & 51 | 9·766 | 59 & 69 | 5·319 | 78 & 88 | 1·759 |
| 4 & 14 | 14·106 | 23 & 33 | 12·648 | 42 & 52 | 9·548 | 60 & 70 | 5·044 | 79 & 89 | 1·657 |
| 5 & 15 | 14·334 | 24 & 34 | 12·510 | 43 & 53 | 9·329 | 61 & 71 | 4·779 | 80 & 90 | 1·515 |
| 6 & 16 | 14·419 | 25 & 35 | 12·365 | 44 & 54 | 9·104 | 62 & 72 | 4·529 | 81 & 91 | 1·450 |
| 7 & 17 | 14·432 | 26 & 36 | 12·214 | 45 & 55 | 8·870 | 63 & 73 | 4·302 | 82 & 92 | 1·460 |
| 8 & 18 | 14·395 | 27 & 37 | 12·058 | 46 & 56 | 8·626 | 64 & 74 | 4·094 | 83 & 93 | 1·479 |
| 9 & 19 | 14·321 | 28 & 38 | 11·900 | 47 & 57 | 8·372 | 65 & 75 | 3·921 | 84 & 94 | 1·468 |
| 10 & 20 | 14·221 | 29 & 39 | 11·747 | 48 & 58 | 8·111 | 66 & 76 | 3·746 | 85 & 95 | 1·443 |
| 11 & 21 | 14·106 | 30 & 40 | 11·607 | 49 & 59 | 7·851 | 67 & 77 | 3·580 | 86 & 96 | 1·397 |
| 12 & 22 | 13·987 | 31 & 41 | 11·474 | 50 & 60 | 7·601 | 68 & 78 | 3·407 | 87 & 97 | 1·324 |
| 13 & 23 | 13·864 | 32 & 42 | 11·342 | 51 & 61 | 7·370 | 69 & 79 | 3·210 | 88 & 98 | 1·280 |
| 14 & 24 | 13·737 | 33 & 43 | 11·207 | 52 & 62 | 7·142 | 70 & 80 | 3·020 | 89 & 99 | 1·192 |
| 15 & 25 | 13·608 | 34 & 44 | 11·063 | 53 & 63 | 6·911 | 71 & 81 | 2·807 | 90 & 100 | 0·950 |
| 16 & 26 | 13·483 | 35 & 45 | 10·912 | 54 & 64 | 6·669 | 72 & 82 | 2·616 | 91 & 101 | 0·733 |
| 17 & 27 | 13·359 | 36 & 46 | 10·750 | 55 & 65 | 6·418 | 73 & 83 | 2·430 | 92 & 102 | 0·508 |
| 18 & 28 | 13·235 | 37 & 47 | 10·579 | | | 74 & 84 | 2·260 | 93 & 103 | 0·235 |

# ANNULOSA.*

General Arrangement.

The Linnean arrangement of the Animal Kingdom has, with some slight emendations, been adopted as the ground-work of the zoological articles contained in the later editions of the *Encyclopædia*. In these Supplemental volumes, we propose to introduce all the recent discoveries in Zoology, and also to avail ourselves of the opportunity thus afforded, of describing the various classes of animals under an arrangement more accordant to the improved views of Science, and to the Order of Nature. We shall have occasion fully to explain the principles upon which our system is founded, in the article Zoology. At present, it is only necessary to mention, that all the different branches of this grand department of Natural History will be treated of under these heads; *viz.* Annulosa, Cirrhipedes, Insecta, Mollusca, Radiata, and Vertebrosa. From these heads, references will be made to the zoological articles in the body of the work, and also from the older names to the corresponding appellations in the arrangement adopted in these volumes.

The term Annulosa (from *Annulus*, a ring or segment), is applied to animals whose bodies are more or less divided transversely into segments.

General Arrangement.

This type of animals was proposed in one of the last volumes of the *Annales de Muséum*, by M. G. Cuvier. It comprehends *five* classes, the classification of which will form the subject of the present article.†

As the leading characters of the classes are very obvious, we shall, in the first place, lay them before our readers through the medium of a table, and shall then detail them more fully.

Class 1. Crustacea. Branchiæ or gills for respiration. Legs ‡ for motion.

Class 2. Myriapoda. || Tracheæ or air-tubes for respiration. Legs more than eight. Head distinct from the thorax. Antennæ two.

Class 3. Arachnides. Tracheæ for respiration. Legs eight or six. Head not distinct from the thorax. Antennæ none.

Class 4. Insecta. Tracheæ for respiration. Legs six. Head distinct from the thorax. Antennæ two.

Class 5. Vermes. Tracheæ for respiration. Legs none. Antennæ none.

## Class I.—CRUSTACEA.

### *History.*

All the Crustacea, as their name imports, are enveloped in a crust or shell (*crusta*). Many of the larger species were known to ancient Naturalists. They were named Crustacea by the Latins, Malacostracoi (Μαλακόστρακοι) by the Greeks. Aristotle has dedicated a chapter to the species known to him; Athenæus enumerates those used as food; and Hippocrates has made mention of such species as were considered useful in medicine.

To the observations of Aristotle, very little was added by Pliny; and from his time until that of Rondeletius, Belon, Gesner, Aldrovandus, and Johnson, who placed the Crustacea between the Fishes and Mollusca, little or nothing was done that tends in any way to elucidate the natural history or structure of these animals.

By the great reformer Linné, they were arranged under the genera Monoculus, Cancer, and Oniscus, along with apterous insects; but the most prejudiced of his followers now admit that they have characters sufficient to establish them as a distinct class.

J. C. Fabricius, a pupil of Linné, divided the Crustacea from insects, and formed several distinct classes for their reception; but as he has altered his system in his different works, it seems necessary only to state the last, which is given in the Supplement to his *Entomologia Systematica*. In this work is the following arrangement:

Class Polygonata. Many maxillæ within the lip.

Gen. 1. Oniscus, 2. Ligia, 3. Idotea, 4. Cymothoa, 5. Monoculus.

Class Kleistagnatha. Many maxillæ, closing the mouth. Lip none.

Gen. 1. Cancer, 2. Calappa, 3. Ocypode, 4. Leucosia, 5. Parthenope, 6. Inachus, 7. Dromia, 8. Dorippe, 9. Orithyia, 10. Portunus, 11. Matuta, 12. Hippa, 13. Symethis, 14. Limulus.

Class Exochnata. Many maxillæ outside the lip, covered by the palpi.

Gen. 1. Albunea, 2. Scyllarus, 3. Pallinurus, 4. Palæmon, 5. Alpheus, 6. Astacus, 7. Penæus, 8. Crangon, 9. Pagurus, 10. Galathea, 11. Squilla, 12. Posydon, 14. Gammarus.

Before the publication of this work, Müller (in

* The animals which compose this type are partly treated of in the Articles Entomology and Helminthology of the *Encyclopædia*.

† For the comparative characters of this type, see Zoology. In the present article, we propose to give the characters and economy of the Genera, and an example of one Species of each, with the exception of Insecta, which will be treated of under that head in a separate article.

‡ By this term, we mean those organs which actually perform the functions of legs. On this subject more will be said under the article Zoology.

|| This class was instituted by Dr Leach. Latreille comprehended the animals composing it under the general denomination Arachnides.

Crustacea. 1792) produced his celebrated work on the *Entomostraca*, which contains several crustaceous genera, which he disposed into the following groups.

Division I. MONOCULI. With but one eye.

* *Shell univalve.*

Gen. 1. Amymone, 2. Nauplius. (These two genera, Jurine of Geneva has discovered to be but larvæ of the genus Cyclops of Müller.)

** *Shell bivalve.*

Gen. 3. Cypris, 4. Cythere, 5. Daphnia.

*** *Shell composed of a solid crust.*

Gen. 6. Cyclops, 7. Polyphemus.

Div. II. BINOCULI. With two eyes.

* *Shell univalve.*

Gen. 8. Argulus, 9. Caligus, 10. Limulus.

** *Shell bivalve.*

Gen. 11. Lynceus.

A great portion of the species, composing the Entomostraca of Müller, were described by the microscopic observers, Joblot, Frish, Réaumur, De Geer, Baker, Ledermüller, and Geoffroy, and were by the latter author arranged into two genera, which he named Binoculus and Monoculus.

By that learned anatomist G. Cuvier, the Crustacea were considered as forming a class, which he placed between the Vermes and Insecta. This indefatigable observer discovered, that the Crustacea breathed by branchiæ or gills, and he disposed them into three great sections, viz.

I. MONOCULUS, including the genera, 1. Limulus, 2. Caligus, 3. Cyclops, 4. Apus, 5. Polyphemus of Müller:

II. CANCER, comprehending the genera, 6. Cancer, 7. Inachus, 8. Astacus, 9. Palinurus, 10. Squilla, 11. Scyllarus of Fabricius:

III. ONISCUS, including, 12. Physodes, 13. Oniscus, 14. Cymothoa of Fabricius.

Lamarck, in his *Systême des Animaux sans Vertebres,* has disposed the Crustacea into the two following orders, viz.

Ord. I. CRUSTACE'S PE'DIOCLES, including the genera, * 1. Cancer, 2. Calappa, 3. Ocypode, 4. Grapsus, 5. Dorippe, 6. Portunus, 7. Podophthalmus, 8. Matuta, 9. Maja, 10. Porcellana, 11. Leucosia, 12. Arctopsis, ** 13. Albunea, 14. Hippa, 15. Ranina, 16. Scyllarus, 17. Astacus, 18. Pagurus, 19. Galathea, 20. Palinurus, 21. Crangon, 22. Palæmon, 23. Squilla, 24. Branchiopoda.

Ord. II. CRUSTACE'S SESSILIOCLES, * 25. Gammarus, 26. Asellus, 27. Caprella, 28. Oniscus, 29. Cyamus, 30. Ligia, 31. Cyclops, ** 32. Polyphemus, 33. Limulus, 34. Daphnia, 35. Amymone, 36. Cephaloculus. With the second section, Lamarck has placed the genus Forbicina (Lepisma saccharina of Linné), which, in our opinion, belongs to the genuine class Insecta.

By Dumeril (*Zoologie Analatique*), these animals are placed in two orders, which are divided into families.

Ord. I. ENTOMOSTRACE'S.

*Fam.* 1. ASPIDIOTES. Gen. 1. Limulus, 2. Calius, 3. Binoculus, 4. Ozolus, 5. Apus.

*Fam.* 2. OSTRACINS. Gen. 6. Lynceus, 7. Daphnia, 8. Cypris, 9. Cythere.

*Fam.* 3. GYMNONECTES. Gen. 10. Argulus, 11. Cyclops, 12. Polyphemus, 13. Zöe, 14. Branchiopoda. Crustacea.

Ord. II. ASTACOIDES.

*Fam.* 4. CARCINÖIDES. Gen. 15. Calappa, 16. Hepatus, 17. Dromia, 18. Cancer, 19. Matuta, 20. Portunus, 21. Podophthalmus, 22. Porcellana, 23. Ocypode, 24. Grapsus, 25. Pinnotheres.

*Fam.* 5. OXYRINQUES. Gen. 26. Maja, 27. Leucosia, 28. Dorippe, 29. Orithyia, 30. Ranina.

*Fam.* 6. MACROURES. Gen. 31. Pagurus, 32. Albunea, 33. Hippa, 34. Scyllarus, 35. Palinurus, 36. Galathea, 37. Astacus, 38. Penæus, 39. Palæmon, 40. Crangon.

*Fam.* 7. ARTHROCE'PHALES. Gen. 41. Squilla, 42. Mysis, 43. Phronima, 44. Talitrus, 45. Gammarus.

The genera, 46. Oniscus, 47. Physodes, and 48. Armadillo, he has placed with apterous insects.

Bosc, in his *Histoire Naturelle des Crustacés,* has adopted, with some slight modifications, the system of Lamarck: he divides the Crustacea into two sections, viz.

Sec. I. CRUSTACE'S PE'DIOCLES. Eyes pedunculated.

*Div.* 1. Body short; tail flat, simple, applied against the lower part of the abdomen.

Gen. 1. Cancer, 2. Calappa, 3. Ocypode, 4. Grapsus, 5. Dorippe, 6. Portunus, 7. Podophthalmus, 8. Orithyia, 9. Matuta, 10. Dromia, 11. Porcellana, 12. Leucosia, 13. Pinnotheres, 14. Maja.

*Div.* 2. Body oblong; tail elongated, terminated with appendices.

Gen. 15. Albunea, 16. Posydon, 17. Hippa, 18. Ranina, 19. Scyllarus, 20. Astacus, 21. Pagurus, 22. Galathea, 23. Palinurus, 24. Crangon, 25. Palæmon, 26. Alpheus, 27. Penæus, 28. Squilla, 29. Branchiopoda.

Sec. II. CRUSTACE'S SESSILIOCLES. Eyes sessile.

*Div.* 1. Body covered with several crustaceous segments.

Gen. 1. Zöe, 2. Gammarus, 3. Talitrus, 4. Caprella, 5. Asellus, 6. Idotea, 7. Sphæroma, 8. Ligia, 9. Cyamus, 10. Cymothoa, 11. Cyclops, 12. Bopyrus.

*Div.* 2. Body covered with a crustaceous shield, composed of one or two parts.

Gen. 30. Caligus, 31. Binoculus, 32. Limulus, 33. Apus, 34. Daphnia, 35. Cythere, 36. Cypris, 37. Polyphemus.

We shall now give the system of Latreille, published in his *Considérations Générales.*

Order I. ENTOMOSTRACA.

*Fam.* 1. ASPIDIOTA. Gen. 1. Limulus, 2. Apus, 3. Caligus, 4. Binoculus.

*Fam.* 2. OSTRACODA. Gen. 5. Lynceus, 6. Daphnia, 7. Cypris, 8. Cythere.

*Fam.* 3. GYMNOTA. Gen. 9. Cyclops, 10. Polyphemus, 11. Zöe, 12. Branchiopoda.

Ord. II. MALACOSTRACA.

*Fam.* 1. CANCERIDES. Gen. 13. Podophthalmus, 14. Portunus, 15. Dromia, 16. Cancer, 17. Hepatus, 18. Calappa, 19. Ocypode, 20. Grapsus, 21. Plagusia, 22. Pinnotheres.

*Fam.* 2. Oxyrinchi. Gen. 23. Dorippe, 24. Mictyris, 25. Leucosia, 26. Corystes, 27. Lithodes, 28. Maja, 29. Macropus, 30. Orithyia, 31. Matuta, 32. Ranina.

*Fam.* 3. Pagurii. Gen. 33. Albunea, 34. Remipes, 35. Hippa, 36. Pagurus.

*Fam.* 4. Palinurini. Gen. 37. Scyllarus, 38. Palinurus, 39. Porcellana, 40. Galathea.

*Fam.* 5. Astacini. Gen. 41. Astacus, 42. Thalassina, 43. Alpheus, 44. Penæus, 45. Palæmon, 6. Crangon.

*Fam.* 6. Squillares. Gen. 46. Squilla, 47. Mysis.

*Fam.* 7. Gammarinæ. Gen. 48. Phronima, 49. Gammarus, 50. Talitrus, 51. Corophium, 52. Caprella, 53. Cyamus.

Some other animals which we consider as genuine Crustacea, he has arranged with the class Arachnides; and has formed an order for their reception, named Tetracea, which he has divided into two families, viz.

*Fam.* 1. Asellota. Gen. 54. Asellus, 55. Idotea, 56. Cymothoa, 57. Sphæroma.

*Fam.* 2. Oniscides. Gen. 58. Ligia, 59. Philoscia, 60. Oniscus, 61. Porcellio, 62. Armadillo.

In the article *Crustaceology* of the *Edinburgh Encyclopædia*, Dr Leach gave the system of Latreille, with some modifications; and arranged with the Crustacea those animals which he afterwards separated as a distinct class under the title *Myriapoda*. We shall now lay before our readers a sketch of the system there proposed, as altered by the remarks in the Appendix to that article.

Class. CRUSTACEA.

Subclass I. Entomostraca.

Tribe I. Thecata. Shell shield-shaped.

*Fam.* 1. Xiphosura. Gen. 1. Limulus.

*Fam.* 2. Pneumonura. Gen. 2. Caligus, 3. Binoculus.

*Fam.* 3. Phyllopoda. Gen. 4. Apus.

Tribe II. Ostracoda. Shell bivalve.

*Fam.* 1. Monophthalma. Gen. 5. Lynceus, 6. Daphnia, 7. Cypris, 8. Cythere.

Tribe III. Gymnota. Shell naked.

*Fam.* 1. Pseudopoda. Gen. 9. Cyclops.

*Fam.* 2. Cephalota. Gen. 10. Polyphemus, 11. Zöe, 12. Branchiopoda.

Subclass II. Malacostraca.

Order I. Brachyura.

*Tribe* 1. Cancerides. Gen. 13. Podophthalmus, 14. Lupa, 15. Portunus, 16. Carcinus, 17. Portumnus, 18. Cancer, 19. Xantho, 20. Atelecyclus, 21. Dromia, 22. Hepatus, 23. Ocypode, 24. Uca, 25. Gonoplax, 26. Gecarcinus, 27. Grapsus, 28. Plagusia, 29. Pinnotheres.

*Tribe* 2. Oxyrynchi. Gen. 30. Leucosia, 31. Maja, 32. Parthenope, 33. Hyas, 34. Eurynome, 35. Blastus, 36. Pisa, 37. Inachus, 38. Macropodia (falsely written Septopodia), 39. Megalopa, 40. Corystes, 41. Mictyris, 42. Dorippe, 43. Orithyia, 44. Matuta, 45. Ranina.

Order II. Macroura.

*Tribe* 1. Pagurii. Gen. 46. Albunea, 47. Remipes, 48. Hippa, 49. Pagurus.

*Tribe* 2. Palinurii. Gen. 50. Scyllarus, 51. Palinurus, 52. Porcellana, 53. Galathea.

*Tribe* 3. Astacini. Gen. 54. Astacus, 55. Nephrops, 56. Thalassina, 57. Gebia (misprinted Upogebia), 58. Callianassa, 59. Alpheus, 60. Hippolyte, 61. Pandalus, 62. Penæus, 63. Palæmon, 64. Athanas, 65. Crangon, 66. Mysis (repeated under the generic title Praunus).

Order III. Gasteruri.

*Tribe* 1. Gnathides. Gen. 67. Gnathia.

*Tribe* 2. Gammerides. Gen. 68. Talitrus, 69. Orchestia, 70. Dexamine, 71. Leucothöe, 73. Melita, 74. Mæra, 75. Gammarus, 76. Ampithöe, 77. Pherusa, 78. Corophrium, 79. Podocerus, 80. Jassa.

*Tribe* 3. Phronimarides. Gen. 81. Phronima.

*Tribe* 4. Caprellides. Gen. 82. Cyamus, 83. Caprella, 84. Proto.

*Tribe* 5. Apseudides. Gen. 85. Apseudes.

*Tribe* 6. Asellides. Gen. 86. Anthura, 87. Campecopea, 88. Nesæa, 89. Cymodoce, 90. Dynamene, 91. Sphæroma, 92. Cymothoa, 93. Limnoria, 94. Idotea, 95. Stenosoma, 96. Jæra, 97. Janira.

*Tribe* 7. Oniscides. Gen. 98. Ligia, 99. Philoscia, 100. Oniscus, 101. Porcellio, 102. Armadillo.

Lamarck, in his *Extrait du Cours de Zoologie du Muséum d'Histoire Naturelle*, &c. has given the following classification of these animals:

Order I. Cryptobrancha.

Section I. Brachyuri.

* *Body broader than long, rounded or truncated anteriorly.*

Cancerides.

*a Shore Crabs.*

Genus 1. Cancer, 2. Dromia, 3. Hepatus, 4. Calappa, 5. Ocypode, 6. Grapsus, 7. Plagusia, 8. Pinnotheres.

*b Swimming Crabs.*

Genus 9. Podophthalmus, 10. Portunus, 11. Matuta, 12. Orithyia.

** *Body subtriangular, terminated anteriorly in a point.*

Oxyrhynci.

Genus 13. Dorippe, 14. Leucosia, 15. Macropus, 16. Arctopsis, 17. Maja.

Section II. Macrouri.

* *Tail furnished with ciliæ or hooks.*

Pagurii.

Genus 18. Porcellana, 19. Corystes, 20. Ranina, 21. Albunea, 22. Hippa, 23. Pagurus.

** *Tail furnished with swimming scales.*

Astacini.

Genus 24. Scyllarus, 25. Palinurus, 26. Astacus, 27. Galathea, 28. Crangon, 29. Alpheus, 30. Palæmon.

Order II. Gymnobrancha.

Section I. Pediocculi.

Squillarii.

Genus 31. Squilla, 32. Mysis, 33. Branchiopoda.

Section II. Sessioculi.

Genus 34. Caprella, 35. Phronima, 36. Gammarus, 37. Asellus, 38. Idotea, 39. Cymothoa, 40. Sphæroma, 41. Ligia, 42. Oniscus, 43. Cyamus.

Section III. Entomostraca.

1. *With two eyes.*

Genus 44. Polyphemus, 45. Limulus, 46. Caligus, 47. Ozolus, 48. Zöe, 49. Lynceus.

2. *With one eye.*

Genus 50. Daphnia, 51. Cytherea, 52. Cypris, 53. Cyclops, 54. Cephaloculus.

Having given a sketch of the systems adopted by these authors, we shall proceed to detail that proposed by Dr Leach in the Second Part of the eleventh Volume of the *Transactions of the Linnean Society of London*.

*Classification.*

Subclass I. Entomostraca. *Legs* branchial, or furnished with appendages. *Mandibles* wanting or simple. *Eyes* sessile or pedunculated.

Subclass II. Malacostraca. *Legs* simple, without appendages. Mandibles palpigerous. *Eyes* pedunculated or sessile.

### Subclass I. ENTOMOSTRACA.

The animals of this subclass are but little known, and consequently their arrangement is extremely imperfect. Some of the genera are parasitic, being found on the bodies of other animals, and some even undergo transformation during their growth.

The following arrangement is artificial; but is well calculated to enable the student to discover the genera.

*Synopsis of the Genera.*

Division I. Body covered by a horizontal shield. Eyes sessile.

*Subdivision* 1. Shield composed of two distinct parts.

Gen. 1. Limulus.

*Subdivision* 2. Shield composed of but one part.

* *With jaws.*

Gen. 2. Apus.

** *With a rostrum, but no jaws.*

*a* Antennæ, four.

Gen. 3. Argulus.

*b* Antennæ, two.

4. Cecrops, 5. Caligus, 6. Pandarus, 7. Anthosoma.

Division II. Body covered by a bivalve shell. Eyes sessile.

*Subdivision* 1. Head porrected.

Gen. 8. Lynceus, 9. Chydorus, 10. Daphnia.

*Subdivision* 2. Head concealed.

Gen. 11. Cypris, 12. Cythere.

Division III. Body covered neither by a bivalve shell or shield. Eye one, sessile.

Gen. 13. Cyclops, 14. Calanus, 15. Polyphemus.

Division IV. Body covered by neither a bivalve shell or shield. Eyes pedunculated.

Gen. 16. Branchiopoda.

#### Division I. *Subdivision* 1.

Gen. 1. Limulus, *Müller, Fabr.* &c.

Xiphosura, *Gronovius.*

Polyphemus, *Lamarck.*

*Shell* coriaceous, rounded in front, narrower behind; *anterior shell* largest, somewhat lunate, convex, with three carinæ or keels; *eyes* two, ovate, very small, and scarcely prominent, one on each side of the lateral carina; *hinder shell* somewhat triangular, truncate-marginate, the sides toothed, having a moveable spine between each tooth; *tail* horny, three-sided, articulated to the notched extremity of the second shell by a hinge-like joint.

*Antennæ* none.

*Mandibles* two, two-jointed, inserted under the anterior margin of the shell, their bases meeting; the second joint furnished with a moveable thumb-like process.

*Legs* ten, didactyle; fifth pair longest, the last joint but one with its extremity bearing elongate lamellæ; anterior legs internally spinose near their base.

All the Limuli inhabit the sea. *Monoculus Polyphemus* of Linné belongs to the genus.

*Limulus heterodactylus* and *L. virescens* of Latreille, probably form two distinct genera, belonging to the same subdivision.

Sp. 1. *Sowerbii.* Anterior shell with seven spines, arranged 1, 3, 3; hinder shell with five, 3, 1, 1, the lateral spines elongate and simple; tail above somewhat spinulose.

Limulus Sowerbii. *Leach, Zool. Miscel.* ii. 72. tab. 84.

The locality of this species, which is extremely common, is unknown.

*Subdivision* 2. *

Gen. 2. Apus. *Cuvier, Latreille, Leach.*

Apos, *Scopoli.*

*Shell* crustaceous-membranaceous, orbiculate-ovate, behind deeply emarginate; the back, with the exception of the anterior part, carinated; *eyes* two, inserted at the anterior and middle part of the back, somewhat prominent, slightly lunate, approaching each other, especially anteriorly where they touch each other.

*Antennæ* two, short, somewhat filiform, biarticulated, scarcely esserted, inserted behind the mandibles.

*Mandibulæ* two, corneous, somewhat cylindric, short, hollow within, points arcuated and compressed, the extreme apex strait and very much denticulated.

*Legs* branchial and very numerous.

The Api inhabit stagnant waters and ponds their anterior legs are spiny at the base, like those of the Limuli.

Sp. 1. *Montagui.* Carina of the shell produced into a point behind; anterior legs with articulated setæ; no lamella between the caudal setæ.

Plate XX. fig. 1. *Apus Montagui*, natural size; 2. anterior leg magnified; 3. part of one of the setæ of the anterior leg highly magnified; 4. setæ of the tail magnified.

Inhabits England, near Christ-church in Hampshire, where it was discovered by Montagu, who sent it to Dr Leach as the Linnean *Monoculus apus.*

*Apus productus* of Latreille, is synonymous with the Linnean *Monoculus apus.*

*Subdivision* 2. ** *a.*

Gen. 3. Argulus, *Müller, Jurine, Leach.*

Binoculus, *Geoffroy, Latreille.*

*Shell* oval, somewhat membranaceous, semi-transparent, anteriorly rounded, behind deeply notched; *eyes* two, hemispheric, inserted at the anterior and lateral parts of the clypeus.

*Antennæ*, very small, inserted above the eyes.

*Rostellum* sterniform.

*Legs* twelve, unequal in size and form; *first pair* shorter, very membranaceous, capable of changing their form, broader at their tips, and formed for adhering to objects; *second pair* prehensile, curved, much thicker towards their base, the thighs furnished with three spinules beneath; tarsi three-jointed, the last joint with two claws and a pulvillus; *four hinder pair* inserted at the sides of the abdomen, somewhat cylindric, formed for swimming, with their points bifid.

*Abdomen* cylindric; *tail* bilobate.

Sp. 1. *Foliaceus*, Jurine.

Argulus delphinus. *Müll. Entom.* 123.
Monoculus argulus. *Fabr. Ent. Syst.* ii. 489.
Monoculus gyrini. *Cuv. Tab. Elém.* 454.
Binoculus gasterostei. *Latr. Gen. Crust. et Ins.*
Argulus foliaceus. *Jurine, An. de Museum*, vii. 451.
Argulus argulus. *Leach, Edin. Encycl.* vii. 388.

This species, which is the only one of the genus that has hitherto been noticed, inhabits ponds and rivulets, adhering to the larvæ of frogs and to fishes.

The larva has been described by Müller as a destinct species, under the name *Argulus charon:* in this state it differs from the full grown animal in size, and in having four cylindric, equal, biarticulated, penicillated oars, two of which are attached to the animal above the eyes, and are furnished at their tips with four setæ, the other two below the eyes being terminated with three setæ: The two anterior legs are incrassated, elongated, and terminated by a strong bent claw.

The full grown animal lays from one to four hundred eggs, which are ovate and smooth, being generally deposited on stones in two contiguous longitudinal series. These eggs are hatched in about thirty days.

*Subdivision* 2. ** b.

Gen. 4. Cecrops. New Genus.

*Shell* coriaceous-membranaceous, composed of two parts; the *anterior segment* inverse heart-shaped, deeply and obtusely notched behind; anteriorly notched; the laciniæ rounded and externally bearing the antennæ. *Antennæ* two-jointed, the first joint largest, thickest, the second bearing at its point a simple seta; *hinder segment* smaller, inversely heart-shaped, occupying the notch of the anterior segment.

*Abdomen* of the breadth of the shell, notched behind.

*Rostrum* elongate-conic, perpendicular, inserted between the middle and anterior legs; having on each side of its base a moveable ovate appendage.

*Legs* six; *anterior pair* biarticulated with a strong curved claw; *second pair* triarticulate, more slender, the last joint double, the exterior joint shortest; *third* pair strong, uniarticulate, with a very strong claw. *Four legs* spurious, placed behind the others, double, the double parts biarticulate, situated on a common coxa.

Female with two large ovate connected bags of a coriaceous substance, situated beneath the abdomen and projecting behind, in which she carries her eggs.

Sp. 1. *Latreillii.*

Plate XX. fig. 1. male; 2. female; 3. under side of male; 4. under side of female; 5. antennæ magnified, 6. Anterior leg magnified; 7. hinder leg magnified; 8. middle leg.

Of this curious animal the history is unknown. That it is parasitic its structure evidently shows, and from analogy we may infer, that it is an inhabitant of the ocean, and that it attaches itself to the larger marine animals. There are several specimens preserved in the British Museum.

Gen. 5. Caligus, *Müll. Latr. Bosc*, &c.

*Shell* coriaceous-membranaceous, bipartite; the anterior segment inversely cordiform, very deeply notched behind (the notch receiving the hinder segment, which is round), the anterior part subproduced, notched; the laciniæ at their base externally bearing antennæ; *antennæ* biarticulate, the first joint thickest, the second with a simple seta at its extremity.

*Abdomen* narrower than the thorax; with its base contracted and bearing the hinder legs, its extremity on each side with a rounded process of the length of the body. *Rostrum* rounded, rather more slender towards its apex, which is obtuse. *Legs* fourteen; anterior, second, and fourth pairs with a strong claw; the second pair short; the third slender elongate, the last joint double, with unequal laciniæ; the fifth with the last joint on one side setose, the setæ ciliated on each side; the sixth with a double triarticulated tarsus, the last joints on each side setose, the setæ ciliated on each side; the seventh part with its last joint trifid.

The hinder segment of the thorax beneath, terminated by a large broad lamella, ciliated behind.

*Caligus curtus* of Müller, forms the type of this genus.

Sp. 1. *Mülleri.*

Plate XX. fig. 1. Natural size; 2. magnified; 3. seventh leg; 4. fifth leg; 5. one of the ciliated setæ of the fifth leg much magnified; 6. third leg; 7. fourth leg; 8. sixth leg.

Inhabits the common cod-fish. It was first sent to us by Dr Spalding, of Edinburgh, to whose kindness we are indebted for several very curious animals.

Gen. 6. Pandarus. New genus.

Caligus, *Müller, Latr. Bosc, Leach*, &c.

*Shell* coriaceous-membranaceous, composed of but one part, deeply notched behind; the angles acute; the middle of the notch toothed; anteriorly narrower, rounded, with a process on each side externally bearing the antennæ. *Antennæ* composed of two joints, the second joint terminated by several setæ. *Abdomen* somewhat narrower than the shell, the base above with two transverse lamellæ, the first of which is four-lobed, the second bilobate; the apex notched, with two filaments, longer than the body, with a lamella at their base above. *Rostrum* elongate, attenuated, inserted behind the anterior legs. *Legs* fourteen; anterior pair short, terminated by a short claw, and arising from beneath an ovate process; second pair with a double unequal tarsus; third pair without any determinate form, without any claw; fourth pair bifid; fifth and sixth pairs bifid, their coxæ connected by a lamella; seventh pair bifid, the exterior lacinia longest, with a notch externally towards its apex.

Sp. 1. *Bicolor.* Shell and the middle of the abdominal lamellæ black; tail with filaments double the length of the body.

Inhabits the *Squalus galeus* of Linné.

Sp. 2. *Boscii.* Body entirely pale, testaceous; tail with filaments once and an half the length of the body.

Inhabits the *Squalus mustelus* of Linné.

Plate XX. fig. 1. *Pandarus Boscii* natural size; 2. magnified; 3. anterior leg magnified; 4. antenna magnified; 5. sixth leg magnified; 6. seventh leg magnified; 7. fifth leg magnified; 8. fourth leg magnified; 9. second leg magnified; 10. third leg magnified.

Gen. 7. Anthosoma. New genus.

*Shell* coriaceous-membranaceous unipartite, rounded before and behind; the anterior part as if unilobate, the lobe higher than the shell, behind on each side, bearing the antennæ; *antennæ* six-jointed. *Abdomen* much narrower than the shell, on every side imbricated with membranaceous foliaceous lamellæ which surround or embrace it. Two of the lamellæ are dorsal, the one being placed over the other; the other lamellæ are placed on the sides of the belly, three on each side; apex of the abdomen terminated by two very long filaments, and with two shorter filaments below them. *Rostrum* elongate cylindric, inserted behind the anterior legs, furnished at its extremity with two strait corneous mandibles. *Legs* six; anterior pair three-jointed, the second joint near the apex above unidentate, the last terminated by a claw; second pair triarticulated, the last joint ovate, compressed; third pair biarticulate, the second joint very thick, internally dentated, armed at its extremity by a strong claw.

Sp. 1. *Smithii.* Plate XX. fig. 1. natural size; 2. two specimens adhering to part of the gill-cover of a shark; 3. antenna magnified; 4. middle leg magnified; 5. hinder leg magnified; 6. anterior leg magnified.

This species was discovered sticking to a shark which was thrown ashore on the coast of Exmouth in Devon, by T. Smith, Esq. of Paper Buildings, Temple. He informed the writer of this article, that it adhered solely by means of its anterior legs to the axillæ and gill-covers, which were much thickened by the inflammation caused by their irritation.

Division II. *Subdivision* 1.

Gen. 8. Lynceus, *Müll. Latr. Bosc, Leach.*

*Eyes* two. *Antennæ* four, capillary.

Sp. 1. *Brachyurus.* Shell globose; tail deflexed.

Lynceus brachyurus.
*Müll. Entomost.* 69. tab. 8. f. 1. 12.
*Bosc, Hist. Nat. des Crust.* ii. 264.
*Leach, Edin. Encycl.* vii. 388.
*Latr. Gen. Crust. et Ins.* i. 17.

Monoculus brachyurus.
*Fabr. Ent. Syst.* ii. 407.

Inhabits marshes; is very common in the spring, moving about with great agility amongst aquatic plants. The female carries her eggs on the posterior and superior part of her belly.

Gen. 9. Chydorus.

Lynceus, *Müll. Latr. Bosc, Leach.*

*Eyes* two. *Antennæ* two, capillary.

Sp. 1. *Sphæricus.* Shell globose; tail inflexed.

Lyncæus sphericus.
*Müll. Entomost.* 71. t. ix. f. 7, 9.
*Latr. Gen. Crust. et Ins.* i. 17.
*Bosc, Hist. Nat. des Crust.* ii. 264.
*Leach, Edin. Encycl.* vii. 388.

Monoculus sphericus.
*Fabr. Ent. Syst.* ii. 497.

Gen. 10. Daphnia.
*Müll. Latr. Bosc, Leach.*

*Eye* one only. *Antennæ* two, branching.

The extraordinary appearance presented by the animals of this genus caused them to be mentioned by Leuwenhoeck, Needham, Swammerdam, and other microscopical investigators. Their shell, although apparently bivalve, is formed but of one piece, open in front. Their head is terminated by a kind of pointed but immoveable beak. Their mouth is placed within the shell. The eye is absolutely single, and not formed by the union of two eyes, and is covered by granules. The number of legs is not known. One of the species is called Pulex caudatus by Schœffer, 1755, t. 1. f. 1. 8. and in the *Encyclopædia Britannica*, Pl. 37. fig. 1, a species is rudely figured as an animalcule.

Sp. 1. *Pulex.* Tail inflexed; shell mucronated behind.

Monoculus pulex.
*Linn. Faun. Suec.* 2047.
*Fabr. Ent. Syst.* ii. 491.

Daphnia pennata.
*Müll. Entom.* 82. t. 12. f. 4. 7.

Daphnia pulex.
*Latr. Gen. Crust. et Ins.* i. 18.
*Leach, Edin. Encycl.* vii. 338.

Inhabits ponds and marshes. Geoffroy (*Hist. des Insect.* ii. 655.) has given a description of this species under the very expressive name of *Monocle le Perroquet d'eau.*

*Subdivision* 2.

Gen. 11. Cypris. *Müll. Latr. Bosc, Leach.*

*Antennæ* terminated by a brush.

Many of the *Cyprides* were noticed by Joblot, Ledermuller, Baker, and De Geer, but they were first reduced to one genus by the illustrious Müller.

The animals of this genus inhabit pools and ditches, containing pure water; they swim with very great rapidity, and, whilst in motion, conceal their whole body within their shell, which is truly bivalve. The members of the body of the cyprides are not known; they move with such quickness whilst living, and are so soft when dead, that it is scarcely possible to investigate their characters more fully. Their antennæ are long, and very flexible; these organs are furnished at their tips with a brush or pencil, composed of hairs. The hinder part of their bodies is formed of a tail, which is almost entirely concealed within their shell. Their head is terminated by an elongate point, and they have but one eye. Of their economy nothing is known, but they have been observed to change their covering like other Entomostraca.

Plate XX. fig. 1. Cypris nephröides natural size; 2. magnified.

Sp. 1. *Conchacea.* Shell ovate, tomentose.

Monoculus conchaceus.
*Linn. Fn. Suec.* 2050.
*Fabr. Ent. Syst.* ii. 496.

Cypris pubera.
*Müll. Entomost.* 56. t. 5. f. 1. 5.

Cypris conchacea.
*Latr. Gen. Crust. et Insect.* i. 18.
*Leach, Edin. Encycl.* vii. 388.
Inhabits France, Germany, and England.

Gen. 12. CYTHERE. *Müll. Latr. Bosc, Leach.*
*Antennæ* simply pilose.

This genus was first discovered and established by Müller, who first observed all the species described in his Entomostraca. It is distinguished from *Cypris* by the antennæ, which are not terminated by a pencil of hairs. The legs are eight in number, and are rarely drawn within the shell, which is really bivalve.

The Cytheres have no tail, and their antennæ, like those of the Cyprides, have their articulations pilose. They have but one eye. All the species inhabit the sea, and may be found among the confervæ and corallines, which fill the pools left by the tide in most of the rocky coasts of Europe.

Sp. 1. *Viridis.* Shell reniform, velvety, and green.
Cythere viridis. *Müll. Entomost.* 64, tab. 7. f. 1. 2.
*Latr. Gen. Crust. et Ins.* i. 19.
*Bosc, Hist. Nat. des Crust.* ii. 261.
*Leach, Edin. Encycl.* vii. 388.
Inhabits the European Ocean. Is occasionally found on the shores of Scotland amongst fuci and confervæ.

Division III.

Gen. 13. CYCLOPS, *Müll. Lam. Latr. Bosc, Leach.*
*Body* ovate-conic, elongate. *Eye* one, situated on the thorax. *Antennæ* four, simple. *Legs* eight.

All the animals of this genus inhabit fresh waters. The females carry their eggs in a pouch resembling a bunch of grapes on each side of the tail. The organs of generation of the male are placed in the antennæ; those of the female beneath the belly, at the base of the tail, which is abruptly narrower than the abdomen. The antennæ are hairy at the base of their joints.

Sp. 1. *Geoffroyii.* Tail strait and bifid; colour brownish.
Monoculus quadricornis.
*Linn. Fn. Su.* 2049.
*Fabr. Entom. Syst.* ii. 500.
Cyclops quadricornis.
*Müll. Entomost.* 109. t. 18. f. 1. 14.
*Latr. Gen. Crust. et Insect.* i. 19.
*Bosc, Hist. Nat. des Crust.* ii. 228. pl. 18. f. 4. female.
*Leach, Edin. Encycl.* vii. 388.
Inhabits Europe. Is very common in fresh waters. Geoffroy, in his *Histoire Naturelle des Insectes* (tom. ii. 656. pl. 21. f. 5.), has described and figured this species under the title *Le Monocle à queue fourchue.* It was first noticed by Leuwenhoeck, and his observations were afterwards increased by those of Baker, Roesel, and De Geer.

Gen. 14. CALANUS.
CYCLOPS, *Müll. Latr. Bosc, Leach.*
*Body* ovate conic, elongate. *Eye* one, situated on the thorax. *Antennæ* two, simple. *Legs* eight.
Cyclops longicornis.
*Müll. Entomost.* 115. t. 19. f. 7, 9.
*Latr. Gen. Crust. et Insect.* i. 20.
*Bosc, Hist. Nat. des Crust.* ii. 229.
*Leach, Edin. Encycl.* vii. 389.
Monoculus longicornis.
*Fabr. Ent. Syst.* ii. 501.
Inhabits the Norwegian and German Ocean. It was first discovered by the celebrated Gunnerus in the Finmarchian Sea, and was described by Müller in his *Zoologiæ Danicæ Prodromus*, under the title Cyclops Finmarchicus, which name he afterwards changed in his *Entomostraca.*

Gen. 15. POLYPHEMUS, *Müll. Latr. Bosc, Leach.*
CEPHALOCULUS. *Lamarck.*
*Eye* one, forming the head; *legs* ten; two bifid, elongate, and extended horizontally.

This genus, containing one species, was established by Müller. Naturalists have generally considered it as the larva of some other genus, but the multiplied observations of Müller, Lamarck, and Bosc, have cleared up all doubts on the subject, and it is now generally admitted as a distinct and perfect animal. The head is round, distinct from the thorax, and apparently composed of one large eye. The body is divided into two parts by a kind of contraction; the anterior part contains the legs and tail; the posterior part contains only the eggs and the young. The tail is long, and is attached to the under part of the body, being terminated by two setæ.

The *polyphemus* inhabits marshes and moves quickly by the combined efforts of its short legs and bifid oars, generally swimming on its back.

Sp. 1. OCULUS. Body luteous, with a few blue spots.
Polyphemus oculus.
*Müll. Entom.* 119. pl. 20, f. 1. 5.
*Latr. Gen. Crust. et Insect.* i. 20.
*Bosc, Hist. Nat. des Crust.* ii. 290. pl. 18. f. 5. 6.
*Leach, Edin. Encycl.* vii. 389.
Cephaloculus stagnorum.
*Lam. Syst. des Anim. sans Vert.* 170.
Inhabits lakes and marshes. In the *Edinburgh Encyclopædia*, Dr Leach stated it as probable that there were several species that had been confounded with *P. oculus;* but repeated observations have since convinced him of the error of this conjecture, and led to the conclusion that there is but one, which is subject to very considerable variation in size and colour.

Division IV.

Gen. 16. BRANCHIOPODA,
*Lam. Latr. Bosc, Leach.*
*Body* filiform and very soft. *Head* divided from the thorax by a very narrow but distinct neck. *Eyes* two, lateral. *Antennæ* two, short, two-jointed, capillary inserted behind and above the eyes. *Front* with two moveable processes (which are broader towards the apex in the male sex), that are notched, those of the female furnished with a papilla at their point.

*Subsidiary Observations.* In the front of the male, at the base of the moveable processes on the front, are two long hair-like filaments, and the clypeus is, as it were, double. In both sexes, the mouth is armed with a hooked rostriform papilla, supported by four little processes. The trunk of the body is keel-shaped, and is formed of eleven joints, each of which is furnished with two branchial feet, the anterior pair with two, the posterior pairs with three lamellæ. The tail is about the length of the body, composed of

six or nine obscure joints, the oval segment bearing two fins.

The organs of generation are situate at the base of the tail.

Sp. 1. *Stagnalis.* Body transparent, of a light brown colour, slightly tinged with green or blue, particularly on the head and legs.

Cancer stagnalis. *Linn. Fn. Su.* 2043.

Branchiopoda stagnalis.

*Lam. Syst. des Anim. sans Vert.* 161.

*Latr. Gen. Crust. et Ins.* i. 22.

*Leach, Edin. Encycl.* vii. 389.

We shall transcribe the ingenious observations made on this species by the late Dr Shaw of the British Museum, published in the first volume of the *Transactions of the Linnean Society of London.*

"It is generally found in such waters as are of a soft nature, and particularly in those shallows of rain-water which are so frequently seen in the spring and autumn, and in which the *Monoculus pulex* of Linnæus, and other small animals, abound. At first sight, it bears some resemblance to the larva of a dytiscus; but, when viewed closely, it is found to be of a much more curious and elegant appearance than that animal. The legs, of which there are several pair (eleven?) on each side, are flat and filmy, and have the appearance of so many waving fins, of the most delicate structure imaginable. The whole animal is extremely transparent, and the general colour is brown, slightly tinged with blueish-green.

"*Monoculus conchaceus* of Linnæus very frequently assaults them, and adheres with such force to their tails and legs, as sometimes to tear off a part in the struggle. It delights much in sunshine, during which it appears near the surface of the water, swimming on its back, and moving in various directions, by the successive undulations of its numerous fin-like legs, and moving its tail in the manner of a rudder. On the least disturbance, it starts in the manner of a small fish, and endeavours to secret itself, by diving in the soft mud. It changes its skin at certain periods, as is evident from the exuviæ or shoughs being frequently found in the water in which these animals are kept.

"In March and April, the females deposit their eggs without any settled order, and perfectly loose in the water. They appear to the naked eye, like very minute globules of a light brown colour. Each ovum, when magnified, closely resembles the farina of a mallow. It is thickly beset with spines on every side, and coated over with a transparent gelatinous substance, reaching just to the extremities of the spines, and is most probably intended to assist in causing them to adhere to the substances on which they may chance to fall, or as a security from the attacks of smaller animals. In about a fortnight or three weeks, the eggs are hatched, and the young animals may be seen to swim with great liveliness, by means of three very long pair of arms or rowers, which appear disproportionate to the size of the animal, and indeed it bears, in this very small state, not much resemblance to the form it afterwards assumes; but, in the short space of a very few hours, the body assumes a lengthened form, and begins to acquire the tail-fin. The eyes in this state do not appear pedunculated. On the seventh day after hatching, they approach pretty nearly the form of the perfect animal; they, however, still retain the two first pairs of rowers or arms. The legs are at this period very visible. About the ninth day it loses the long oars, and appears still more like the animal in its advanced state."

The Doctor farther observes, that it is highly probable, that a considerable time elapses before the animal assumes its full size, but the time he was unable to determine, as those he kept died before they had acquired any considerable size. When first hatched, they are scarcely larger than the common mite.

## Subclass II. MALACOSTRACA.

This subclass has occupied a very considerable portion of attention, the result of which shall be given in the following pages.

Legion I. PODOPHTHALMA. *Eyes* pedunculated or elevated on footstalks.

Order I. Brachyura. *Tail* short and simple at its extremity.

Order II. Macroura. *Tail* lengthened with appendices at its extremity.

Legion II. EDRIOPHTHALMA. *Eyes* sessile.

### Legion I. PODOPHTHALMA.

The *Malacostraca podophthalma* include those animals, which, in common language, are denominated Crabs, Lobsters, Cray-fish, Prawns, Pandals, and Shrimps, all of which have the power of reproducing their claws when they are lost.

Crabs and Lobsters are said "to change their crust annually," but this, like many other statements in zoology, is incorrect. We have seen *Maja squinado* and the common Lobster (*Astacus gammarus*) so overgrown with Ostreæ, Anomiæ, Flustræ, Spongiæ, and Sertulariæ, as scarcely to be enabled to move the joints of their legs, and as the oysters were of a year's growth, and as the anomiæ were above them, and the coralline matters upon the anomiæ, there can be no doubt but the crust was at least two years old.

### Order I. Brachyura.

Latreille arranges the *Brachyura* (from the proportional breadth and length of the thorax or shell) into two families; but the discovery of genera, unknown to that illustrious Entomologist, has convinced us that such a distribution is extremely unnatural; and although, from the infant state of our knowledge, we cannot venture to propose named divisions; yet we shall endeavour to dispose the genera into what appear to be natural groupes.

*Synopsis and distribution of the Genera.*

A. *Abdomen of the male five-jointed, the middle joint longest; of the female seven-jointed. Anterior pair of legs didactyle.*

Division I. Shell nearly rhomboidal. Two anterior legs very long, with deflexed fingers.

Genus 1. Lambrus.

Division II. Shell truncate behind. Two anterior legs of the male elongate, of the female moderate.

*Subdivision* 1. Antennæ long, ciliated on each side.
Genus 2. CORYSTES.
3. THIA.
4. ATELECYCLUS.
*Subdivision* 2. Antennæ moderate, simple. Hinder pair of legs with compressed claws.
Genus 5. PORTUMNUS.
6. CARCINUS.
7. PORTUNUS.
8. LUPA.
*Subdivision* 3. Antennæ moderate, simple. Four hinder pair of legs compressed.
Genus 9. MATUTA.
*Subdivision* 4. Antennæ simple, short. Four hinder pair of legs simple.
Genus 10. CANCER.
11. XANTHO.
12. CALAPPA.
B. *Abdomen in both sexes seven-jointed. Two anterior legs didactyle.*
Division III. Eight hinder legs simple, and alike in form.
*Subdivision* 1. Shell anteriorly arcuated, the sides converging to an angle.
(Two anterior legs unequal).
Genus 13. PILUMNUS.
14. GECARCINUS.
*Subdivision* 2. Shell quadrate or subquadrate. Eyes inserted in the front.
* Shell quadrate. Eyes with a short peduncle.
Genus 15. PINNOTERES.
** Shell quadrate. Eyes with a long peduncle.
Genus 16. OCYPODE.
17. UCA.
18. GONOPLAX.
*Subdivision* 3. Shell quadrate. Eyes inserted at the anterior angles of shell.
Genus 19. GRAPSUS.
Division IV. Two hinder legs at least dorsal.
*Subdivision* 1. Two posterior legs dorsal. Eyes with the first joint of the peduncle elongated.
Genus 20. HOMOLA.
*Subdivision* 2. Four hinder legs dorsal. Eyes with the first joint of the peduncle short.
Genus 21. DORIPPE.
22. DROMIA.
Division V. Shell rostrated in front. Eight hinder legs alike and simple.
*Subdivision* 1. Fingers deflexed.
Genus 23. EURYNOME.
24. PARTHENOPE.
*Subdivision* 2. Fingers not deflexed. External antennæ with the first joint simple. Anterior pair of legs distinctly thicker than the rest.
Genus 25. PISA.
26. LISSA.
*Subdivision* 3. Fingers not deflexed. External antennæ with their first joint simple. Anterior pair of legs scarcely thicker than the others, which are moderately long.
Genus 47. MAJA.
*Subdivision* 4. Fingers not deflexed. External antennæ with the first joint simple. Anterior pair of legs about the thickness of the rest, which are very long and slender.

Genus 28. EGERIA.
29. DOCLEA.
*Subdivision* 5. Fingers not deflexed. External antennæ with the first joint externally dilated.
Genus 30. HYAS.
C. *Abdomen in both sexes six-jointed. Two anterior legs didactyle.*
Division VI. Fifth pair of legs minute, spurious.
Genus 31. LITHODES.
Division VII. Second, third, fourth, and fifth pair of legs alike and slender.
*Subdivision* 1. Eyes retractile.
Genus 32. INACHUS.
*Subdivision* 2. Eyes not retractile.
Genus 33. MACROPODIA.
D. *Abdomen of the male six-jointed: of the female five-jointed; the last joint very large. Eyes not retractile.*
Division VIII.
Genus 34. LEPTOPODIA.
35. PACTOLUS.
E. *Abdomen of both sexes four-jointed. Two anterior legs didactyle.*
Division IX.
Genus 36. LEUCOSIA.
37. IXA.
The following genera belong to this order, but their situation has not yet been fixed, namely,
Genus 38. HEPATUS.
39. PLAGUSIA.
40. MICTYRIS.
41. ORITHYIA.
42. RANINA.
43. MEGALOPA.

A. Division I.

Gen. 1. LAMBRUS. *Leach.*
*External antennæ* simple. *External double palpi*, with the second joint of their internal footstalk, internally notched for the insertion of the palpi.
Sp. 1. *Longimanus.* Thorax spiny, the spines simple: arms smooth beneath.
Parthenope longimana. *Fabr. Ent. Syst. Supl.* 353.
Maja longimana.
*Bosc, Hist. Nat. des Crust.* i. 250. pl. 7. f. 1.
Lambrus longimanus.
*Leach, Trans. Linn. Soc.* xi. 310.
This species inhabits the Indian Ocean.

Division II. *Subdivision* 1.

Gen. 2. CORYSTES, *Latr. Leach.*
*External antennæ* longer than the body, the third segment composed of elongate, cylindric joints. *External double palpi* with the internal footstalk narrow, the second joint largest, having its internal side broadly emarginate. *Anterior pair of legs*; of the male twice the length of the body, subcylindric, the hand gradually somewhat thicker and somewhat compressed; of the female of the length of the body, with a compressed hand: *other legs* with tibiæ and tarsi of equal length; *claws* elongate, strait, acute and longitudinally sulcated. *Abdomen* of the male with the first joint linear transverse, the second longer and produced on each side, third nearly equally quadrate, the fourth transverse and narrower than the third, the fifth narrower, nearly triangular, with the tip rounded; of the female with six first joints transverse ar-

cuated in front, seventh triangular, with the apex rounded. *Shell* oblong-ovate, anteriorly slightly rostrated, behind margined. *Eyes* not thicker than their bending-backward peduncles; *orbits* above with one fissure.

Sp. 1. *Cassivelaunus.* Shell granulated, crenulated behind; front bifid; the sides tridentate.

Cancer cassivelaunus.
*Penn. Brit. Zool.* iv. 6. t. 7. male and female.
*Herbst*, i. 195. t. 12. f. 72. male.
Cancer personatus. *Herbst*, i. 193. t. 12. f. 71. female.
Albunea dentata. *Fabr. Supl. Ent. Syst.* 398.
*Bosc, Hist. Nat. des Crust.* ii. 4.
Corystes dentatus. *Latr. Gen. Crust. et Ins.* i. 40.
Corystes cassivelaunus.
*Leach, Edinb. Encycl.* vii. 395.
——. *Trans. Linn. Soc.* xi. 312.

C. cassivelaunus inhabits most of the sandy shores of the European Ocean, and are often thrown up after heavy gales of wind. Latreille formerly considered the male as a distinct species, under the title Corystes longimanus.

Gen. 3. Thia. *Leach.*

*External antennæ* longer than the body, the third segment composed of elongate cylindric joints. *External double palpi* with the second joint of their internal footstalk much shorter than the first, with its internal apex truncate-emarginate. *Anterior pair of legs* of the male a little longer than the body, with the hand compressed: *other legs* with the tarsi half the length of the tibiæ, with acute flexuous claws, which are longitudinally sulcated. Abdomen of the male with the first joint transverse, arcuate, linear; the second a little longer, anteriorly slightly arcuately produced; the third very long, narrower towards the apex, which is slightly emarginate; the fourth subquadrate, apex slightly notched; the fifth triangular. *Shell* somewhat circular with the sides gradually converging into an angle behind; hinder part somewhat granulate-margined; the front somewhat produced. *Eyes* very small, scarcely prominent; *orbit* without any fissure behind.

Sp. 1. *Polita.* Shell convex, polished and sprinkled with punctures; orbit behind emarginate; sides on each side obscurely four-folded; front entire and arcuate.

Cancer residuus. *Herbst*, iii. 53. t. 48. f. 1?
Thia polita. *Leach, Trans. Linn. Soc.* xi. 312.

Locality unknown.

Gen. 4. Atelecyclus. *Leach.*

*External antennæ* half the length of the body, the third segment composed of elongate and cylindric joints. *External double palpi* with the second joint of the internal footstalk shortest, with the internal apex produced, and the internal side notched towards the joint. *Anterior legs* of the male longer than the body, with a compressed hand; of the female as long as the body, with a compressed hand: *other legs* with tibiæ and tarsi of equal lengths, furnished with elongate, quadrate nails, that are longitudinally sulcated, having their tips naked, rounded and sharp, the hinder ones obscurely subcompressed. Abdomen of the male with the first joint transverse, linear, twice the length of the second; the third much elongated, narrower towards its extremity, the apex nearly strait; the fourth subquadrate, with the anterior angles produced; fifth flask-shaped, with a very sharp extremity; of the female with the first five joints transverse, and of nearly an equal length; the sixth joint transverse quadrate, anteriorly notched, the last elongate, subtriangular behind, subproduced. *Shell* subcircular, the sides gradually converging into an angle behind; hinder part truncate and granulate-margined. *Eyes* narrower than their footstalks; *orbits* behind with two fissures, below with one.

Sp. 1. *Heterodon.* Shell granulated, the sides with seven serrulated teeth, and other smaller teeth between some of the other teeth: Front with three serrulated teeth, the middle of which is the largest.

Cancer *(hippa)* septem-dentatus.
*Montagu, Trans. Linn. Soc.* xi. tab. 1.
Atelecyclus septem-dentatus.
*Leach, Edinb. Encycl.* vii. 430.
——. *Trans. Linn. Societ.* xi. 313.

This elegant crab was discovered by Montagu on the southern coast of Devon, where it is not an uncommon species in deep water. To the fishermen it is well known by the name of *old-man's face crab.*

Division II. *Subdivision* 2.

Gen. 5. Portumnus. *Leach.*

*Eyes* not thicker than their peduncles; *orbits* entire. *Anterior pair of legs* equal; *other legs* with compressed claws, internally towards their base dilated; *fifth pair* with a compressed, foliaceous, lanceolate claw. *Abdomen* of the male with the fourth joint elongate. *Shell* with the transverse and longitudinal diameters the same.

Sp. 1. *Variegatus.* Shell obscurely granulated on each side with five teeth, the second and third somewhat obsolete; front with three teeth; wrists internally with one tooth.

Cancer *(latipes)* variegatus.
*Planc, de Conch. Min. notis*, p. 34. t. iii. f. 7. B. C. male.
Cancer latipes.
*Penn. Brit. Zool.* iv. 3. t. 1. f. 4. female.
Portumnus variegatus.
*Leach, Edinb. Encycl.* vii. 391.
——. *Malac. Podoph. Britann.* t. iv. male and female.
——. *Trans. Linn. Soc.* xi. 314.

Planc first discovered this species on the shores of the Adriatic sea. It burrows beneath the sand, where it may be found by digging at low water, on most of our sandy shores.

When living it is most beautifully mottled, and the legs are sometimes of a luteous-orange colour.

Gen. 6. Carcinus. *Leach.*

*Eyes* narrower than their peduncles; *orbits* behind and beneath with one fissure. *Anterior pair of legs* unequal, the hands externally smooth; *hinder pair* compressed, and slightly formed for swimming. *Abdomen* of the male with the fourth joint transverse, and scarcely narrower than the third. *Shell* with the transverse diameter greatest.

Sp. 1. *Mænas.* Shell with five teeth on each side; front with three rounded teeth or lobes: hands with one tooth, wrist with a spine.

Cancer Mænas of authors.

Carcinus Mænas.
*Leach, Edinb. Encycl.* vii. 390.
—— *Trans. Linn. Societ.* xi. 314.

This most common species inhabits all the shores and estuaries of Britain. It burrows under the sand, or conceals itself beneath fuci and stones. It is sent to London in immense quantities, and is eaten by the poor.

Gen. 7. PORTUNUS. *Fabr. Latr. Bosc, Lam. Leach.*

*Eyes* much thicker than their peduncles; *orbits* behind with two fissures, below with one fissure. *Abdomen* of the male with the fourth joint transverse. *Anterior pair of legs* somewhat unequal, the hands externally with elevated lines, arms generally unarmed; *hinder pair* compressed, foliaceous and formed for swimming. *Shell* with the transverse diameter greatest; the side with five, rarely with six teeth.

* *Hinder claws with an elevated longitudinal line; external double palpi, with the second joint of their internal footstalk, truncate at the internal apex.*

*a* Orbits at the insertion of the antennæ imperfect. Wrists bidentate.

Sp. 1. *Puber.* Antennæ half the length of the body, shell pubescent, front with many teeth.
Cancer puber. *Linn. Syst. Nat.*
Cancer velutinus. *Penn. Brit. Zool.* iv. 8. pl. iv. fig. 8.
Portunus puber.
*Latr. Gen. Crust. et Ins.* i. 27.
*Leach, Edin. Encycl.* vii. 390.
—— *Trans. Linn. Soc.* xi. 315.

Inhabits the rocky shores of the Mediterranean Sea and European Ocean. It is very common all along the southern coasts of Devon. In France it is used as an article of food.

*b.* Orbit internally slightly imperfect. Wrists unidentate.

Sp. 2. *Corrugatus.* Shell convex, with transverse serrate-granulate ciliated lines, the sides with five teeth on each side, the three hinder of which are more acute; front trilobate, the lobes subgranulate-serrate, the middle one largest; hands above unidentate, hinder claws with sharp points.
Cancer corrugatus.
*Penn. Brit. Zool.* iv. 5. pl. v. fig. 9.
Portunus corrugatus.
*Leach, Edin. Encycl.* vii. 390.
—— *Trans. Linn. Soc.* xi. 315.

Inhabits the British Seas. Pennant observed it opposite to Loch Jura in Sky, and the young state has been taken by C. Prideaux, Esq. in the Plymouth Sound.

** *Hinder claws without the elevated line. External double palpi with the internal apex of the second joint of the internal footstalk emarginate. Orbits internally beneath the insertion of the antennæ imperfect.*

Sp. 3. *Marmoreus.* Shell convex, obsoletely and slightly granulated, with five nearly equal teeth on each side; front with three equal teeth, with rounded points; hands smooth, with one tooth above; hinder tarsi with acute points.
Cancer (*pinnatus*) marmoreus.
*Montagu's MS.*
Portunus marmoreus.
*Leach, Edin. Encycl.* vii. 390.
—— *Malacost. Podophth. Britan.* tab. 8.
—— *Trans. Linn. Soc.* xi. 317.

This elegant species, which derives its name from its colour, was discovered by G. Montagu, Esq. It is very common on the sandy shores of southern Devon, from Torcross to the mouth of the river Ex, and is frequently found entangled in the shore-nets of the fishermen, or thrown on the shore after storms.

It is distinguished from every other discovered species, by the rounded dentations of the front, the very slight elevation of the lines on the hands, and by the convexity, remarkable smoothness, and marbled appearance of the shell.

Young specimens are plain brown, and much resemble the young of *P. depurator*, from which they may very easily be separated by their more considerable convexity.

Gen. 8. LUPA. *Leach.*

*Eyes* much thicker than their peduncles; orbit above with two fissures, beneath with one fissure. *Anterior pair of legs* equal, the arms anteriorly spinose; *hinder pair* very much compressed. *Abdomen* of the male with the fourth joint much lengthened, much narrower than the third. *Shell* very transverse, furnished on each side with nine teeth, the last of which is the longest.

This genus was instituted by Dr Leach in the *Edinburgh Encyclopædia*, and has since been given, with amended characters, in the *Zoological Miscellany*, and in the eleventh volume of the *Transactions of the Linnean Society.* As far as we have been enabled to learn, all the species inhabit the Great Ocean, harbouring amongst floating marine plants, swimming with great swiftness and ease near the surface of the water.

* *Shell on each side terminated by a very long spine.*

*a.* Fingers very long and filiform, hands externally smooth.

Sp. 1. *Forceps.* Shell granulated, wrists with a spine on each side, hands above at the base, and externally at the base, with one spine; fingers slightly bending upwards, and denticulated within; hinder claw very much compressed, round ovate.
Portanus forceps.
*Fabr. Suppl. Ent. Syst.* 368.
*Bosc, Hist. Nat. des Crust.* i. 220.
Cancer forceps. *Herbst,* iii. t. 55. fig. 4.
Lupa forceps.
*Leach, Zool. Miscel.* i. 123. t. 54.
—— *Trans. Linn. Societ.* xi. 319.

Plate XXI. This curious Lupa inhabits the Carribean Sea. It was first figured by Dr P. Browne, in his *History of Jamaica.*

*b.* Fingers moderately long; hands externally with elevated lines.

Sp. 2. *Trispinosa.* Shell granulated, arms anteriorly with three spines.
Lupa trispinosa. *Leach, Trans. Linn. Soc.* xi. 319.

** *Shell with the hinder lateral spine not very long.*

Sp. 3. *Banksii.* Shell pubescent, front with four teeth, arms anteriorly with five teeth.
Lupa Banksii. *Trans. Linn. Soc.* xi. 319.

A. Division II. *Subdivision* 3.

Gen. 9. MATUTA.

*Dald. Fabr. Lam. Bosc, Latr. Leach.*

*External double palpi*, with the internal footstalk, elongate-subtriangular, the second joint with the internal side excavated and palpigerous. *Fourth pair of legs*, with the claw acute and narrower than the others. *Shell* very transverse on each side, terminated by a long spine.

Sp. 1. *Victor*. Shell on every side punctate, not striated behind.

Matuta victor. *Latr. Gen. Crust. et Insect.* i. 42.

Inhabits the Indian Ocean.

A. Division II. *Subdivision* 4.

Gen. 10. CANCER *of authors.*

*External antennæ* short, inserted between the internal canthus of the eye and the front; *internal antennæ* placed in foveolæ in the middle of the clypeus, with their peduncle nearly lunate. *External double palpi* with the second joint of the internal footstalk notched at the internal apex. *Shell* margined behind; *orbits* behind with one fissure, and externally with one fold; beneath with one fissure and externally with one fold. Anterior pair of legs unequal.

Sp. 1. *Pagurus*. Shell granulated with nine folds on each side; front with three lobes.

Cancer pagurus *of authors*.

This species is the common crab of Britain. It is considered to be in season between Christmas and Easter, and about harvest, being much esteemed as an article of food. Its natural history is but little known. During the summer months, it is very abundant on all our rocky coasts, especially where the water is deep. At low tide, they are often found in holes of rocks, in pairs, male and female; and if the male be taken away, another will be found in the hole at the next recess of the tide. By knowing this fact, an experienced fisherman may twice a-day take, with little trouble, a vast number of specimens, after having once discovered their haunts.

In the winter, they are supposed to burrow in the sand, or to retire to the deeper parts of the ocean. They are taken in wicker-baskets, resembling mouse-traps, or in large nets with open meshes, which are placed at the bottom of the ocean, and baited with garbage.

Gen. 11. XANTHO. *Leach*.

*External antennæ* very short, inserted in the internal corner of the eye; *internal antennæ* received in foveolæ under the prominent margin of the clypeus, the peduncle sublinear. *External double palpi*, with the second joint of the internal footstalk notched at the internal apex. *Shell* submargined behind; *orbits* entire above, below externally with one fissure; *anterior pair of legs* unequal.

Sp. 1. *Florida*. Wrists above with two tubercles; shell on each side with four obtuse teeth; the interstices cut out; fingers black.

Cancer floridus.

*Montagu, Trans. Linn. Societ.* xi. 85. t. 2. f. 1.

Cancer incisus. *Leach, Edin. Encycl.* vii. 391.

Xantho incisa. *Leach, Edin. Encycl.* vii. 430.

Xantho florida. *Leach, Trans. Linn. Societ.* xi. 320.

This species was first described by Montagu, who considered it to be the *Cancer floridus* of Linné; but an examination of the characters in the Amœnitates Academicæ, will readily convince the naturalist of the incorrectness of this opinion; nor is it the *Cancer floridus* of Herbst; which induces me to believe that some one must have misled Mr Montagu with regard to the synonym, as he could never have considered them the same, had he examined the reference.

Cancer donone of Herbst, probably is referable to the genus Xantho.

Gen. 12. CALAPPA. *Dald. Fabr. Lam. Latr. Bosc, Leach.*

*Shell* with the hinder angles arched, receiving the legs when contracted. *Hands* crested, and equal.

One of the species is very common in the Mediterranean Sea, and is mentioned by Aristotle and Athenæus. Of the economy of the genus nothing is known, but, from the general structure of the parts, it is probably similar to that of Cancer.

Sp. 1. *Granulatus*. Shell tuberculated, the hinder angles dentated; hinder teeth strong, acute; hinder margin subemarginated at the base of the tail.

Calappa granulata.

*Fabr. Supl. Ent. Syst.* 346.
*Latr. Gen. Crust. et Insect.* i. 28.
*Bosc, Hist. Nat. des Crust.* i. 184.
*Leach, Edinb. Encycl.* vii. 391.

Inhabits the Mediterranean Sea.

B. Division III. *Subdivision* 1.

Gen. 13. PILUMNUS. *Leach*.

*External double palpi*, with the second joint of the internal footstalk with the internal apex truncate-emarginate. *Claws* simple, with naked tips.

Sp. 1. *Hirtellus*. Body and legs bristly; shell with five teeth on each side; claws somewhat muricated on the outside.

Cancer hirtellus.

*Linn. Syst. Nat.* 1045.
*Penn. Brit. Zool.* iv. 6. p. 6. f. n.
*Leach, Edinb. Encycl.* vii. 391.

Inhabits the south coast of Devonshire.

Gen. 14. GECARCINUS. *Leach*.

*External double palpi*, with the internal footstalk composed of two nearly equal joints; *palpi* inserted beneath or within; *anterior pair of legs*, unequal; *claws* and *tibiæ* spinose; shell truncate-subcordate.

There are probably many species of this genus, but their characters have not been made out by naturalists. Travellers speak of three sorts. Their economy is very curious, and is detailed by Sloane, Catesby, and others.

They inhabit the mountains of the Antilles. In the beginning of the year they descend from the mountains in vast numbers, and deposit their eggs in the sea. During this march, which is said to be conducted with great regularity, and to be under the guidance of a commander, the strongest proceed first. They are often obliged to halt for want of rain, and to go into the most convenient encampment until the weather change. The main body is said to consist of females, which never leaves the mountains till the rain be set in. They chiefly proceed during the

Crustacea. night, sheltering in hollow trees and in shady places during the hot part of the day.

Sp. 1. *Ruricola.* Tarsi with six elevated, serrated lines; hands smooth.

Cancer ruricola.

*Linn. Syst. Nat.* 2040.
*Fabr. Supl. Ent. Syst.* 339.
*Herbst*, tab. 3. f. 36.

Ocypode ruricola.

*Bosc, Hist. Nat. des Crust.* i. 196.
*Leach, Edinb. Encycl.* vii. 393.

Gecarcinus ruricola.

*Leach, Edinb. Encycl.* vii. 330.
—— *Trans. Linn. Societ.* xi. 322.

Inhabits Southern America.

B, Division III. *Subdivision* 2. *

Gen. 15. Pinnoteres. *Latr. Bosc, Leach.*

Alphæus. *Daldorff.*

*Antennæ* very short (the three first joints largest), inserted in the interior corner of the eyes. *External double palpi*, with the internal footstalk, one-jointed. *Anterior pair of legs* unequal. *Eyes* thick. *Shell* ovate-orbicular, orbiculate-quadrate, or transverse-subquadrate.

All the species of this most interesting genus, inhabit the bivalve shells of the acephalous Mollusca, and were supposed by the ancients to be consentareous inmates with the animal, bound by mutual interest. The fable is beautifully told by Oppian, and is alluded to by Cicero. "*Pinna verò (sic enim Græcè dicitur), duabus grandis patulis conchis, cum parva squilla quasi societatem coit comparandi cibi. Itaque cùm pisciculi parvi in concham hiantem innativerint, tum admonita à squilla pinna morsu, comprimit conchas.*" Nat. Deor. Lib. ii. sec. 48.

Aristotle supposed them to act as centinels, and believed that they guarded the pinna (the animal in whose shell they were first observed), from the attacks of its enemies. Rondeletius and some other naturalists held the same opinion.

Sp. 1. *Cranchii.* Shell orbiculate-subquadrate, soft, very smooth, with the sides dilated behind; front strait, obscurely subemarginate; hands oblong, below and the thighs above with a ciliated line; thumb subarcuate; abdomen very broad, the sides of the segments arcuate, the second, and following ones distinctly notched; the fifth segment somewhat broader; the last narrower than the preceding segment. *Female.*

Pinnoteres Cranchii.

*Leach, Malacost. Podophth. Britann.* tab. 14. fig. 4—5.

The male of this species, which was discovered by Mr J. Cranch, whose name it bears, is unknown. It is distinguished from *P. pisum* (the common species), by the form of the front of the shell, which is strait and slightly notched; by the dilated hinder part of the shell, and by the abdomen, all the joints of which, excepting the first, are distinctly notched behind.

Plate XXI.

Division III. *Subdivision* 2. **.

Gen. 16. Ocypode.

*Dald. Fabr. Latr. Lam. Bosc, Leach.*

*Eyes* very large, with their peduncle generally extending beyond their tips, in the form of a spine. *Anterior pair of legs* unequal. Crustacea.

The economy of the *Ocypodes* is unknown, but it is probably not very different from that of the *Ucæ*. They inhabit the shores of the sea; and, as their name indicates, run with great swiftness.

Sp. 1. *Ceratophthalma.* Arms granulated; hands cordate; spine of the peduncle of the eye smooth and very long.

Ocypode Ceratophthalma.

*Fabr. Supl. Entom. Syst.* 465.
*Latr. Gen. Crust. et Ins.* i. 32.
*Leach, Trans. Linn. Soc.* xi. 322.

Inhabits the shores of the Indian Ocean.

Gen. 17. Uca. *Leach.*

Ocypode. *Latr. Bosc, Fabr.* &c.

*Eyes* small, terminating their peduncle. *Anterior pair of legs* very unequal.

The *Ucæ* inhabit the shores of the sea, swamps, and the banks of rivers, living in holes beneath the ground. They multiply very much, and serve as food to otters, bears, birds, crocodiles, &c. The females carry about their eggs under the abdomen. They live on animal substances, which they devour with avidity. Their motion is rapid; Sir J. Banks assures us that he could never come up with them when running, and that the only means by which he could take them was by running to and stopping their holes before they could reach it, and which he effected by lying in ambush until the animals had gone to a very considerable distance from their haunts.

Sp. 1. *Una.* Shell with one tooth on each side.

Cancer vocans major. *Herbst*, t. i. f. 10.

Cancer vocans. *Bosc, Hist. Nat. des Crust.* i. 198.

Uca una. *Leach, Trans. Linn. Soc.* xi. 323.

Inhabits South America.

Gen. 18. Gonoplax. *Leach.*

Ocypoda. *Bosc.*

*Eyes* terminating their peduncle. *Anterior pair of legs* equal; of the male very long; of the female twice the length of the body. *Antennæ* half of the length of the body, inserted at the internal canthus of the eyes.

The animals of this genus inhabit the ocean, preferring such parts as have a slimy bottom. They burrow laterally in the clay or slime, making two entrances to their hole; entering by one, and going out by the other. We have seen several fossil species inclosed in marle, that appear to belong to this genus.

Sp. 1. *Bispinosa.* Shell on each side with two spines, arms above, and wrists internally with one spine.

Cancer angulatus. *Penn. Brit. Zool.* iv. t. 5. f. 10.

*Fabr. Supl. Entom. Syst.* 341.

Ocypoda angulata. *Bosc, Hist. Nat. des Crust.* i. 198.

Gonoplax bispinosa.

*Leach, Edinb. Encycl.* vii. 430.
——, *Trans. Linn. Soc.* xi. 323.

Inhabits the British Sea. It is not uncommon at Salcombe and in the Plymouth Sound; and likewise occurs at Weymouth, and at Redwharf in Anglesea.

Division III. *Subdivision* 3.

Gen. 19. Grapsus. *Lam. Latr. Bosc, Leach.*

Crustacea.

Sp. 1. *Pictus.* Shell with the sides plicated behind, anteriorly with the angles bidentate; front with four dentated folds; fingers with their joints concave: wrists internally strongly unidentate.

Cancer grapsus.
*Linn. Syst. Nat.* 1048.
*Fabr. Supl. Ent. Syst.* 342.

Grapsus pictus.
*Latr. Gen. Crust. et Insect.* i. 33.
*Leach, Edinb. Encycl.* vii. 393.
——, *Trans. Linn. Soc.* xi. 323.

Inhabits the South American Ocean.

B. Division IV. *Subdivision* 1.

Gen. 20. Homola. *Leach.*

*Shell* elongate-quadrate, a little produced in front: *eyes* large, somewhat globose, their footstalks lengthened, the second joint very short and very abruptly thicker than the first. *External antennæ* very long, inserted beneath the eyes, the two first joints long, the first thickest: *internal antennæ* inserted within the orbit of the eye, and capable of being lodged in the internal corner. *External double palpi* with their internal footstalk composed of two lengthened and narrow joints; *palpi* three-jointed; the first joint shortest. *Legs* ten; first pair largest and didactyle; the three following pair simple, alike in form, and having their *claws* spiny within; fifth pair monodactyle, the *claws* and *tarsi* being spiny within. *Abdomen* composed of seven joints.

Sp. 1. *Spinifrons.* Shell anteriorly spinous; sides anteriorly beset with small spines; hinder thighs internally with three spines.

Homola spinifrons.
*Leach, Trans. Linn. Soc.* xi. 324.
——, *Zoolog. Miscel.* ii. 82. t. 88.

Inhabits the Mediterranean Sea.

B. Division IV. *Subdivision* 2.

Gen. 21. Dorippe. *Dald. Fabr. Lam. Latr. Bosc, Leach.*

*External double palpi* with the internal footstalk having its first joint dilated interiorly, the second narrow, bearing palpi at its extremity. *Shell* subtriangular, anteriorly truncated. *Second* and third *pair of legs* alike, with acute, elongate, simple subquadrate *claws; fourth* and *fifth pair* shorter, dorsal and monodactyle. *External antennæ* inserted above and between the eyes: *internal antennæ* inserted below and between the eyes.

Sp. 1. *Quadridens.* Middle of the clypeus with four teeth, the lateral ones shortest; sides of the shell unidentate at their middle part; four anterior thighs subdentate.

Dorippe quadridens.
*Fabr. Supl. Ent. Syst.* 361.
*Bosc, Hist. Nat. des Crust.* i. 207.
*Latr. Gen. Crust. et Ins.* i. 41.
*Leach, Edin. Encycl.* vii. 395.
—— *Trans. Linn. Societ.* xi. 324.

Inhabits the Mediterranean Sea.

Gen. 22. Dromia. *Dald. Fabr. Latr. Bosc, Leach.*

*External double palpi* two-jointed, with the second joint somewhat broader, shorter, and at its interior apex palpigerous. *Second* and *third pair of legs* simple; *fourth* and *fifth* shorter and didactyle. *External antennæ* inserted below the eyes; the two first joints largest, and abruptly thicker than the others; *internal antennæ* inserted below, and somewhat between the eyes.

Crustacea.

Sp. 1. *Rumphii.* Shell hairy, on each side with five strong teeth, without any remarkable interval between them; arms and legs without knots.

Cancer Dromia. *Linn. Syst. Nat.* 1043.

Dromia Rumphii.
*Fabr. Supl. Ent. Syst.* 359.
*Leach, Edin. Encycl.* vii. 391.

Inhabits the East Indian Ocean. It is named after Rumphius, by whom it was first described and figured. *Rarit. Amb.* t. 11. No. 1.

B. Division V. *Subdivision* 1.

Gen 23. Eurynome. *Leach.*

*External antennæ* rather long, with the first joint shorter than the second. *Shell* verrucated, anteriorly terminated by a bifid rostrum, with divaricating laciciæ. *Eyes* distant, thicker than their peduncle, which is of moderate length. *External double palpi* with the interior point of the second joint of their internal footstalks truncate-emarginate. *Anterior legs* equal; of the male three times the length of the body; of the female longer than the body.

Sp. 1. *Aspera.* Anterior legs and thighs tuberculated; shell with eight tubercles on the back that are more elevated than the others, which are irregular and margined with hairs; the sides with four lamellæ; rostrum with simple acuminate laciniæ.

Cancer asper. *Penn. Brit. Zool.* iv. 8.

Eurynome aspera.
*Leach, Edin. Encycl.* vii. 431.
——— *Malac. Podophth. Britan.*
——— *Trans. Linn. Societ.* xi. 326.

Inhabits the British Sea.

Gen. 24. Parthenope. *Fabricius, Leach.*

Maja I. *Latreille.*

*External antennæ* very short; the two first joints largest, the first more so than the second. *Shell* tuberose, anteriorly acuminated; the rostrum entire; *eyes* distant, not thicker than their peduncles, which are very short. *External double palpi* with the internal apex of the second joint of their internal footstalk truncate-emarginate. *Anterior legs* unequal; of the male very thick.

Sp. 1. *Horrida.* Tubercles of the shell impressed; the punctures as if eaten; legs spiny; hands and wrists verrucated; abdomen and breast carious.

Cancer longimanus spinosus.
*Seb. Mus.* iii. 48. tab. 19. fig. 16, 71.

Cancer horridus. *Linn. Syst. Nat.* i. 104.

Parthenope horrida.
*Fabr. Suppl. Ent. Syst.* 353.
*Leach, Edin. Encycl.* vii. 431.
——— *Zoologic. Miscel.* ii. tab. 98.

Maja horrida.
*Latr. Gen. Crust. et Insect.* i. 37.
*Leach, Edin. Encycl.* vii. 394.

Inhabits the Asiatic Ocean.

B. Division V. *Subdivision* 2.

Gen. 25. Pisa. *Leach.*

Blastus. *Leach.*

*External antennæ* with clubbed hairs, the first joint longer than the second. *External double palpi* with the second joint of the internal footstalk with its internal apex truncate or emarginate. *Claws* internally denticulated. *Shell* villose, the laciniæ of the rostrum divaricating. *Orbits* behind with two, below with one fissure.

* *Shell densely villose, the sides on each side behind terminated with a spine.*

Sp. 1. *Gibbsii.* Rostrum descending; shell with a spine behind the eyes on each side; arms and thighs simple.

Cancer biaculeatus.
*Montagu, Trans. Linn. Soc.* xi. 2. t. 1. f. 1.
Pisa biaculeata. *Leach, Edin. Encycl.* vii. 431.
Pisa Gibbsii.
*Leach, Trans. Linn. Soc.* xi. 327.
——— *Malac. Podophth. Britan.* tab. 19.

Inhabits deep water on the coasts of Devon and Cornwall.

Sp. 2. Nodipes. Rostrum horizontal; arms and tips of the thighs knotted.

Pisa nodipes.
*Leach, Zool. Miscell.* ii. t. 78.
——— *Trans. Linn. Soc.* xi. 328.

** *Shell villose, with spiny sides.*

Sp. 3. *Tetraodon.* Shell on each side with six spines; two small, the rest larger.

Cancer tetraodon. *Penn. Brit. Zool.* iv. 7. t. 8. f. 15.
Maja tetraodon. *Bosc, Hist. Nat. des Crust.* i. 254.
Blastus tetraodon. *Leach, Edin. Encycl.* vii. 431.
Pisa tetraodon. *Leach, Trans. Linn. Soc.* xi. 328.

Inhabits the south-west coast of England.

Gen. 26. Lissa. *Leach.*

Maja. *Latr. Bosc.*

*External antennæ* with clubbed hairs, the first joint longer than the second. *External double palpi* with the second joint of the internal footstalk truncate-emarginate at the internal apex. *Claws* internally simple, with naked points. *Shell* tuberose, the laciniæ of the rostrum meeting together. *Orbits* with one fissure behind, and one below.

Sp. 1. *Chiragra.* Rostrum obtuse, with the anterior angles subreflexed; legs knotted.

Cancer chiragra. *Herbst,* tab. 17. f. 96.
Inachus chiragra. *Fabr. Supl. Ent. Syst.* 357.
Maja chiragra.
*Bosc, Hist. Nat. des Crust.* i. 255.
*Latr. Hist. Nat. des Crust. et des Insect.* vi. 97.
Lissa charagra. *Leach, Zool. Miscel.* ii. 70. t. 73.

Inhabits the Mediterranean Sea.

Division V. *Subdivision 3.*

Gen. 27 Maja. *Lam. Latr. Bosc, Leach.*

*External antennæ* with two first joints thickest, and of nearly equal length. *Shell* convex ovate-subtriangular, very spiny. *Eyes* not thicker than their elongate peduncle. *External double palpi* with the second joint of their internal footstalk, deeply notched at its internal apex. *Claws* with naked sharp points.

Sp. 1. *Squinado.* Shell fasciculate-pilose, orbit above with one spine, the sides with five strong spines, clypeus beneath the front with a short spine excavated above.

Cancer squinado.
*Herbst,* iii. t. 56. full grown.
——— i. t. 14. f. 85—84. junior.
Cancer maja.
*Scopoli, Entom. Carn.* 1126.
*Sowerby, Brit. Miscell.* t. 39.
Maja squinado.
*Latr. Gen. Crust. et Insect.* i. 37.
*Bosc, Hist. Nat. des Crust.* i. 257.
*Leach, Edinb. Encycl.* vii. 394—431.
——— *Trans. Linn. Societ.* xi. 326.

Inhabits the southern coasts of Devon and Cornwall. By the fishermen it is named Thornback, or king-crab.

B. Division V. *Subdivision 4.*

Gen. 28. Egeria. *Leach.*

*Shell* spinous anteriorly, terminated by an elongate rostrum; *eyes* large, much thicker than their peduncles; *orbits* behind with two fissures, below with one fissure. *External antennæ* inserted at the sides of the rostrum with the two first joints thickest, the second joint much thicker than the first. *Two anterior legs* of the male about twice the length of the body, filiform, and scarcely thicker than the others; *eight hinder legs* very long very slender, alike in form, in order of size 2, 3, 4, and 5. *Claws* elongate, somewhat arcuate, and very slender. *External double palpi* with the second joint of the internal footstalk with its internal side strait, the interior apex being abruptly produced.

Sp. 1. *Indica.* Beak acutely notched; shell behind the beak with six tubercles, arranged in transverse lines, 3, 2, 1, 1.

Doclea Indica. *Leach, Zool. Miscel.* ii. 40. tab. 73.

Inhabits the Indian Ocean, where it is by no means uncommon.

Gen. 29. Doclea. *Leach.*

*Shell* villose, with the sides somewhat spinous; front terminated by a short beak; *eyes* moderate in size, but much thicker than their peduncles; *orbits* behind and below with one fissure. *External antennæ* inserted at the base of the beak, the second joint shorter than the first. *Anterior pair of legs* of the female as long as the body, and more slender than the *others,* which are very long and slender; *claws* elongate, arcuate, slender. *External double palpi* with their internal footstalk having the internal side of the second joint towards the apex deeply notched.

Sp. 1. *Rissonii.* Shell and legs with brown pubescence; hinder part of the shell with one spine; each side with three spines.

Doclea Rissonii. *Leach, Zool. Miscel.* ii. 42. tab. 74.

Locality unknown.

B. Division V. *Subdivision 5.*

Gen. 30. Hyas. *Leach.*

*Shell* elongate-subtriangular, subtuberculated, the sides behind the eyes produced into a lanceolate projection; *rostrum* fissured, the laciniæ approximating. *External antennæ* with the first joint dilated, larger than the second. *External double palpi* with the second joint emarginate at the internal apex.

Crustacea.

Sp. 1. *Araneus.* The lastiform process behind the eyes, tuberculated behind.
Cancer araneus.
*Lin. Syst. Nat.* 1044.
Cancer bufo.
*Herbst*, i. 142. t. 17. f. 59.
Inachus araneus.
*Fabr. Supl. Ent. Syst.* 359.
Hyas araneus.
*Leach, Edin. Encycl.* vii. 437.
—— *Trans. Linn. Soc.* xi. 329.

Inhabits the Scotish Sea in great plenty; on the English coasts it is more rare.

Division VI.

Gen. 31. Lithodes. *Latreille, Leach.*

*External* double palpi with narrow subcylindric footstalks. *Eyes* approximating at their base. *Shell* very spiny, anteriorly rostrated.

Sp. 1. *Maja.* Legs and shell with sharp spines; beak spiny, with the tip bifurcate; fingers with tufts of hair.
Cancer maja.
*Lin. Syst. Nat.* 1046.
Cancer horridus.
*Pen. Brit. Zool.* iv. 7. pl. 7. fig. 14.
Inachus maja. *Fabr. Ent. Syst. Suppl.* 358.
Maja vulgaris.
*Bosc, Hist. Nat. des Crust.* i. 251.
Lithodes arctica.
*Latr. Gen. Crust. et Insect.* i. 40.
Lithodes maja.
*Leach, Edin. Encycl.* vii. 395.
—— *Trans. Linn. Soc.* xi. 332.

Inhabits the Northern Sea, and in our seas is very rare, or at least very local; occurring only on the rocky shores of Yorkshire, and of Scotland.

C. Division VII. *Subdivision* 1.

Gen. 31. Inachus. *Fabricius, Leach.*

Shell slightly spined, with a spine on each side protecting the eye when retracted. *Eyes* distant, scarcely thicker than their peduncles. *External double palpi*, with the second joint of the internal footstalk, truncate at its internal point. *External antennæ* with the three first joints thickest. *Second pair of legs* thicker than the following ones. *Claws* curved.

Sp. 1. *Dorsettensis.* Beak short, emarginate, the clypeus beneath produced into a spine; shell anteriorly with four little tubercles placed transversely; then with three spines (the anterior one strongest); behind with three strong sharp spines (the middle one generally longest and strongest), forming a slightly recurved line; hinder margin with two distinct obsolete tubercles.
Cancer Dorsettensis.
*Pen. Brit. Zool.* iv. 8. pl. 9. fig. 18.
Cancer scorpio.
*Fabr. Sp. Ins.* i. 504.
*Gmel. Syst. Natur.* i. 2078.
*Herbst*, i. 237, 130.
Inachus scorpio.
*Fabr. Ent. Syst. Supl.* 358.
Macropus scorpio.
*Latr. Hist. Nat. des Crust. et des Insect.* vi. 109.
Maja scorpio.
*Bosc, Hist. Nat. des Crust.* i. 252.
Inachus Dorsettensis.
*Leach, Edin. Encycl.* vii. 431.
—— *Malac. Podolph. Britan.* tab. 22. fig. 1—6.
—— *Trans. Linn. Soc.* xi. 330.

Inhabits the British Seas.

Division VI. *Subdivision* 2.

Gen. 32. Macropodia. *Leach.*
Macropus. *Latreille.*

*Shell* slightly spined, beak long and fissured. *Eyes* distant, subreniform, much thicker than their peduncles. *External antennæ* half the length of the body, the second joint three times the length of the first. *External double* palpi slender, the internal footstalk with two equal joints; *palpi* very hairy, the middle joint shortest, the third a little longer than the first. *Four* anterior claws with their tips bent; four hinder ones abruptly curved at their base.

Sp. 1. *Phalangium.* Beak accuminate, much shorter than the antennæ; shell behind the rostrum with three tubercles placed in a triangle, the hinder tubercle largest; arms internally subscabrous and hirsute.
Cancer phalangium.
*Penn. Brit. Zool.* iv. 8. pl. 9. fig. 17.
Macropus longirostris.
*Latr. Gen. Crust. et Insect.*
Macropodia longirostris.
*Leach, Edin. Encycl.* vii. 395.
*Leach, Zool. Miscel.* ii. 18.
—— *Trans. Linn. Soc.* xi. 331.
—— *Malac. Podolph. Britan.* tab. 23.

Inhabits the mouths of rivers, and is very common in Great Britain.

D. Division VIII.

Gen. 33. Leptopodia. *Leach.*

*Shell* not spinous, the beak very long and entire. *Eyes* distant, globose. *External antennæ* half the length of the body, the second joint three times the length of the third. *External double palpi* slender, the internal footstalk, with the second joint half the length of the first. *Palpi* very hairy, the last joint largest, the two first joints nearly equal. *Claws* long, alike in form, and slightly bent.

Sp. 1. *Sagittaria.* Hands granulose; beak on each side, and the arms and thighs anteriorly spinous.
Inachus sagittarius.
*Fabr. Supl. Ent. Syst.* 359.
Cancer sagittarius. *Herbst*, 3.
Macropus sagittarius.
*Latr. Hist. Nat. des Crust. et des Insect.* vi. 112.
Maja sagittaria.
*Latr. Gen. Crust. et Insect.* i. 38, 4.
*Leach, Edin. Encycl.* vii. 395.
Maja sagittis.
*Bosc, Hist. Nat. des Crust.* i. 253.
Leptopodia sagittaria.
*Leach, Zool. Miscel.* ii. 16. tab. 67.
—— *Trans. Linn. Soc.* xi. 332.

Inhabits the Carribean Sea.

Gen. 35. Pactolus. *Leach.*

*Shell* not spiny. *Beak* very long and entire. *Legs* of moderate length; the first, second (and third), pairs furnished with a simple claw; the fourth and fifth pairs didactyle.

The abdomen of the female has the first joint narrow, the second, third, and fourth joints tranverse-linear, the fifth very large and somewhat rounded, as in the case with the genus Leptopodia.

Sp. 1. *Boscii.* Beak on each side spinulose; legs ciliate-punctate.

Pactolus Boscii.

*Leach, Zool. Miscel.* ii. 20. tab. 68.

—— *Trans. Linn. Soc.* xi. 333.

A single specimen of this curious animal is preserved in the British Museum; but its locality is not known. Fabricius seems to have described it as the other sex of his *Inachus sagittarius.*

E. Division IX.

Gen. 36. Leucosia. *Fabr. Latr. Bosc, Leach.*

*Shell* rounded or rhomboidal, slightly produced in front. *External double palpi* with the second joint of their internal footstalk simple. *Anterior pair of legs* distinctly thicker than the others, which are simple.

This genus requires to be investigated. It contains two indigenous species; namely Cancer tumefactus of Montagu, and Cancer tuberosus of Pennant.

* *Second joint of the internal footstalk of the external double palpi dilated.*

Sp. 1. *Anatum.*

Cancer anatum.

*Herbst,* i. 95. tab. 3. fig. 19.

** *Second joint of the internal footstalk of the external double palpi nearly linear.*

Sp. 2. *Craniolaris.*

Cancer craniolaris. *Herbst,* i. 90. tab. 2. fig. 17.

Gen. 37. Ixa. *Leach.*

*Shell* very transverse, subcylindric, much broader than long. *External double palpi* with the second joint of the internal footstalk excavated. *Anterior pair of legs* scarcely thicker than the rest.

Sp. 1. *Cylindrus.* Shell with two channels, the sides rough and terminated by a spine.

Leucosia cylindrus.

*Latr. Hist. Nat. des Crust. et des Insect.* vi. 119.

Cancer cylindrus.

*Herbst,* i. 108. tab. 2. f. 29, 30, 31. male.

Ixa cylindrus.

*Leach, Trans. Linn. Soc.* xi. 334.

Inhabits the Indian Ocean.

*Brachyurous Genera of uncertain situation.*

Gen. 38. Hepatus. *Latreille.*

*External double palpi* with the second joint of their internal footstalk elongate-triangular, gradually becoming sharp from the base to the point. *Shell* arcuate before, the sides converging behind. *Legs* all formed for walking; anterior pair didactyle, the hands crested.

Sp. 1. *Fasciatus. Latreille.*

This species is figured by Herbst, tab. 38. fig. 2. The shell and legs are banded with red, sometimes with brown.

Gen. 39. Plagusia. *Latreille.*

*Eyes* with a short peduncle, inserted at the anterior angles of the shell. *Shell* quadrate. *Interior antennæ* inserted in two fissures on the clypeus.

Sp. 1. *Depressa.* Middle of the clypeus with two teeth; sides of the shell with five teeth; dorsal tubercles naked.

Cancer depressus. *Fabr. Ent. Syst. Suppl.* 343.

Plagusia depressa. *Latr. Gen. Crust. et Insect.* i. 34.

Inhabits the shores of the Mediterranean Sea.

Gen. 40. Mictyris. *Latreille.*

*External double palpi* with the first joint very large. *Antennæ* very short. *Shell* subovate, truncate behind, elevated. *Arms* at the base of the wrist bent like a knee.

Sp. 1. *Longicarpus.*

*Latr. Gen Crust. et Insect.* i. 41.

*Leach, Edin. Encycl.* vii. 395.

Gen. 41. Orithyia. *Daldorff, Fabricius, Latreille, Bosc, Leach.*

*Shell* rounded. *Legs* all placed in the same horizontal line, the hinder pair with the last joint compressed, or formed for swimming; the first pair didactyle.

Sp. 1. *Mamillaris.*

Orithyia mamillaris.

*Fabr. Suppl. Ent. Syst.* 363.

*Latr. Gen. Crust. et Insect.*

Inhabits the Indian Ocean. It is figured by *Herbst,* tab. 18. f. 101.

Gen. 42. Ranina. *Lamarck, Latreille, Leach.*

*Legs,* with the exception of the first pair, which is monodactyle, formed for swimming; the two hinder pairs placed above the others.

Sp. 1. *Serrata.* Arms much dentated; front of the shell with dentated lobes.

Ranina serrata.

*Latr. Gen. Crust. et Insect.* i. 48.

*Leach, Edinb. Encycl.* vii. 396.

Inhabits the Indian Ocean.

Gen. 43. Megalopa. *Leach.*

This genus contains but one species, which is described in the seventh volume of the *Transactions of the Linnean Society,* under the title *Cancer rhomboidalis. Cancer granarius* of Herbst probably belongs to the same genus. See *Trans. Linn. Soc.* vii. tab. vi. fig. 1.

Order II. Macroura.

This order contains the families, *Pagurii, Palinurini, Astacini,* and *Squillares* of Latreille.

*Synopsis and distribution of the Genera.*

A. *Tail on each side with simple appendices.*

Division I. Legs ten; anterior pair largest and dactyle.

Genus 44. Pagurus.

45. Birgus.

B. *Tail on each side with foliaceous appendages, forming with the middle tail-process a fan-like fin.*

a. *Interior antennæ with very long footstalks.*

Division II. External antennæ squamiform. Legs ten, alike and simple.

Genus 46. Scyllarus.

47. Thenus.

Division III. External antennæ setaceous, and very long. Legs ten, alike and simple.

Crustacea.

Genus 48. Palinurus.

Division IV. External antennæ very long and setaceous. Legs ten, anterior pair didactyle, fifth pair spurious.

Genus 49. Porcellana.

50. Galatea.

b. *Interior antennæ with moderate peduncles.*

Division V. Exterior lamella of the tail simple. Antennæ inserted in the same horizontal line, the interior ones with two setæ, the exterior ones simple. Legs ten.

Genus 51. Gebia.

52. Callianassa.

53. Axius.

Division VI. Exterior lamella of the tail bipartite. Antennæ inserted in the same horizontal line, the internal ones with two setæ, the external ones with a spine-shaped squama at the first joint of the peduncle. Legs ten (anterior pair largest and didactyle).

Genus 54. Astacus.

55. Nephrops.

Division VII. External antennæ with a large broad squama or scale at their base. Abdomen with the second joint anteriorly and posteriorly produced below. Legs ten.

*Subdivision* 1. External antennæ inserted in the same horizontal line with the interior ones, which have two setæ. Tail with the external lamella composed of but one part.

Genus 56. Crangon.

*Subdivision* 2. External antennæ inserted below the internal ones; interior ones with two setæ inserted in the same horizontal line. Exterior lamella of the tail bipartite.

Genus 57. Atya.

58. Processa.

*Subdivision* 3. External antennæ inserted below the internal ones; interior ones with two setæ, one placed above the other. (External lamella of the tail composed of but one part).

* *Internal antennæ with the superior seta excavated below. Claws spinulose.*

Genus 59. Pandalus.

60. Hippolyte.

61. Alpheus.

** *Internal antennæ with the superior seta not excavated. Claws simple.*

Genus 62. Penæus.

*Subdivision* 4. External antennæ inserted below the internal; interior ones with three setæ. (External lamella of the tail composed of but one part).

Genus 63. Palæmon.

64. Athanas.

Division VIII. External antennæ inserted below the internal ones, with a large scale at their base. Legs sixteen.

Genus 65. Mysis.

C. Tail with two setæ, one on each side.

Division IX.

Genus 66. Nebalia.

The genera whose situation has not been ascertained are the following, namely,

Genus 67. Albunea.

68. Remipes.

69. Hippa.

Genus 70. Thalassina.

71. Squilla.

Division I.

Gen. 44. Pagurus. *Fabr. Latr. Bosc, Leach*, &c.

*External antennæ*, with the second joint of their peduncle, with a moveable spine affixed to the apex above. *Abdomen* membranaceous. *Tail* three-jointed, crustaceous, the second joint on each side appendiculated. *Four hinder legs* spurious, short, didactyle.

The curious economy of the genus Pagurus attracted the attention of the ancients. One species is well described by Aristotle under the name καρκινιον.

All the species are parasitical, and inhabit the cavities of turbinated univalves. They all change their habitation during their growth, first occupying the smallest shells, and latterly those of very considerable dimensions. The abdomen is naked and slender, being covered merely with a skin of a delicate texture; but its extremity is furnished with appendages, by means of which it secures itself within the shell of which it makes choice. It is really astonishing with what facility these animals move, bearing at the same time the shell, which is destined to preserve the body from injury, and to guard these animals from the attacks of fishes, who would otherwise devour them. All the species are termed indiscriminately *Soldier-crabs* and *Hermit-crabs*, from the idea of their living in a tent, or retiring to a cell.

Sp. 1. *Bernhardus* (common soldier-crab). Arms hairy, muricated, the left the largest; hands subcordate, fingers broad.

Pagurus, Bernhardus.

*Fabr. Suppl. Ent. Syst.* 411.

*Latr. Gen. Crust. et Insect.* i. 46.

*Leach, Edinb. Encycl.* vii. 396.

Cancer Bernhardus. *Linn. Syst. Nat.*

Inhabits the European Ocean, and is very abundant in the British Seas, inhabiting various kinds of univalve shells, changing its habitation as it grows. Pagurus araneiformis, *Edinb. Encycl.* vii. 396, is merely the young of this species.

Gen. 45. Birgus. *Leach.*

*External antennæ* with the second joint of its peduncle crested. *Abdomen* crustaceous. *Tail* two-jointed, crustaceous, the first joint on each side appendiculated. *Fourth pair of legs* didactyle; *fifth pair* (didactyle?).

Sp. 1. *Latro.* Shell anteriorly with a simple acuminate rostrum.

Cancer latro. *Linn. Syst. Nat.* 1049.

Cancer (*astacus*) latro. *Herbst*, ii. 34. tab. 24.

Pagurus latro.

*Fabr. Ent. Syst.* ii. 468.

*Leach, Edinb. Encycl.* vii. 390.

Birgus latro. *Leach, Trans. Linn. Soc.* xi. 337.

This species is said to inhabit Amboyna, and to live in cavities and holes of rocks, from whence it wanders abroad in the night, in order to procure cocoa nuts, on which it is supposed to feed.

Division II.

Gen. 46. Scyllarus.

*Fabr. Dald. Lam. Latr. Bosc, Leach.*

*Hinder legs* with the tarsi beneath produced into

a thumb. *Thorax* convex, sublinear. *Eyes* inserted behind the exterior antennæ.

Sp. 1. *Arctus.* External antennæ very much dentated; shell above with a triple series of dentations. Cancer arctus. *Linn. Syst. Nat.* 1053.
Scyllarus arctus.
*Latr. Gen. Crust. et Insect.* i. 47.
*Leach, Edinb. Encycl.* vii. 397.

Inhabits the European Ocean, and is said by Pennant to have been taken in the British Sea.

Gen. 47. Thenus. *Leach.*

*Hinder legs* with simple tarsi. *Thorax* subdepressed, broader anteriorly. *Eyes* inserted at the anterior angles of the thorax.

Sp. 1. *Indicus.* External antennæ serrated; thorax granulated, carinated, trispinous; abdomen granulated, the granules arranged transversely.

Inhabits the Indian Ocean.

Division III.

Gen. 48. Palinurus.
*Dald. Fabr. Lam. Latr. Bosc, Leach.*

The animals of this genus have the power of producing a sound by rubbing their exterior antennæ against the sides of the projecting clypeus.

Sp. 1. *Vulgaris.*
Astacus homarus. *Penn. Brit. Zool.* iv. 16. pl. 11.

Inhabits the European Ocean. It is commonly eaten in London, and is sometimes denominated spiny-lobster or sea crey-fish.

Division IV.

Gen. 49. Porcellana. *Lam. Latr. Bosc, Leach.*

*External double palpi* with the first joint of the internal footstalk dilated internally. *Shell* orbiculate subquadrate.

Sp. 1. *Platycheles.* Anterior margin of the shell with three entire teeth; claws very large and much depressed; wrists internally denticulated; hands externally deeply ciliated.
Cancer platycheles.
*Penn. Brit. Zool.* iv. 6. pl. 6. and 12.
Porcellana platycheles.
*Latr. Gen. Crust. et Insect.* i. 49.
*Leach, Edinb. Encycl.* vii. 398.
——, *Trans. Linn. Soc.* xi. 339.

Inhabits the rocky shores of the southern and western coasts of Britain, concealing itself beneath stones, to the under side of which it adheres closely.

Gen. 50. Galatea.
Galathea. *Fabr. Latr. Lam. Bosc, Leach.*

*External double palpi* with the internal edge of the first joint not dilated. *Shell* ovate.

* *Rostrum acuminate, acute, with four spines on each side. Anterior legs compressed. Abdomen with the sides of the segments obtuse. Tail with the intermediate lamella triangular, the tip emarginate, the apex of the laciniæ rounded. Interior antennæ with the first joint of the peduncle trispinose.*

a *Second joint of the internal footstalk of the external double palpi longer than the first.*

Sp. 1. *Fabricii.* Anterior legs granulate-spinose; hands externally subserrated; wrists and arms internally spinose. Plate XXI.
Galathea Fabricii. *Leach, Trans. Linn. Soc.* xi. 340.

b. *Second joint of the internal footstalk of the external double palpi shorter than the first.*

Sp. 2. *Spinigera.* Anterior legs subgranulate squamose, above and on each side spinose; arms externally without spines.
Astacus strigosus. *Penn. Brit. Zool.* iv. 18. pl. 14.
Cancer (*astacus*) strigosus. *Herbst,* tab. 26. f. 2.
Galathea strigosa.
*Fabr. Ent. Syst.* ii. 471.—*Suppl.* 414.
*Latr. Gen. Crust. et Insect.* i. 49.
*Leach, Edinb. Encycl.* vii. 398.
Galathea spinigera.
*Leach, Malac. Podoph. Brit.* tab. 28. B.

** *Rostrum elongate, spiniform, the base on each side bispinose. Anterior pair of legs subcylindric. Abdomen with the sides of the segments acute. Tail with the intermediate lamella transverse-quadrate, the apex subemarginate. Interior antennæ with the first joint of the peduncle four-spined. (External double palpi with the first joint of the internal footstalk longer than the second.)*

Sp. 2. *Rugosa.* Anterior legs spinose, especially internally; abdomen with the second segment anteriorly with six, the third with four spines.
Astacus Bamffius. *Pennant, Brit. Zool.* iv. 17. pl. 27.
Galathea rugosa.
*Fabr. Suppl. Ent. Syst.* 415.
*Bosc, Hist. Nat. des Crust.* ii. 87.
*Latr. Hist. Nat. des Crust. et des Insect.* vi. 199. 2.
Cancer rugosus. *Gmelin, Syst. Nat.* i. 2985.
Galathea longipeda. *Lam. Syst. des Anim. sans Vert.* 158.
Galathea Bamffia. *Leach, Edinb. Encycl.* vii. 398.
Galathea rugosa. *Leach, Malac. Podoph. Brit.* tab. 29.
*Trans. Linn. Soc.* xi. 341.

Inhabits the European Ocean and Mediterranean Sea. It is very rare in Britain, but has been found on the Bamffshire coast and in the Plymouth Sound.

Division V.

Gen. 51. Gebia. *Leach.*

*Two anterior legs* equal, subdidactyle, with the thumb short. *Interior* antennæ with an elongate peduncle, the second joint shortest, the third largest and cylindric. *External double palpi* with the third joint of the internal footstalk shortest. *Tail* with broad lamellæ, the exterior ones costated, the middle one quadrate.

Sp. 1. *Deltäura.* Abdomen with the back membranaceous; tail with the apex of the exterior lamella dilated, and somewhat rounded; interior one truncate and formed like the Greek Delta.
Gebia deltäura. *Leach, Trans. Linn. Soc.* xi. 342.

Inhabits beneath the sand on the southern coast of Devonshire, and is found by digging to the depth of two or three feet.

Gen. 52. Callianassa. *Leach.*

*Four anterior legs* didactyle; anterior pair largest, very unequal; second pair less; third pair monodactyle; fourth and fifth pairs spurious. *Internal antennæ* with an elongate biarticulate peduncle, the

second joint longest. *External double palpi* with the second joint of the internal footstalk largest and compressed. *Tail* with broad lamellæ, the middle process elongate-triangular, with the apex rounded.

The thorax anteriorly abruptly subacuminate, the rostriform process divided from the shell by a suture. Anterior pair of legs very much compressed, the hand articulated. The larger leg, with the base of its wrist furnished with a curved process.

Sp. 1. *Subterranea.* Shell with the rostriform process with one longitudinal ridge, the point rounded.
Cancer astacus subterraneus.
*Montagu, Trans. Linn. Soc.* xi.
Callianassa subterranea.
*Leach, Edin. Encycl.* vii. 400.
—— *Trans. Linn. Soc.* xi. 343.

This animal lives beneath the sand on the sea-shore. It was first described by Montagu, who found it by digging in a sand-bank in the estuary of Kingsbridge, on the southern coast of Devon.

Gen. 53. Axius. *Leach.*

*Four anterior legs* didactyle; anterior pair largest, and somewhat unequal; third, fourth, and fifth pairs, furnished with a compressed claw. *Interior antennæ* with a three-jointed peduncle, the first joint longest. *External double palpi* with the two first joints somewhat large and equal. *Tail* broad, the intermediate lamella elongate-triangular.

Sp. 1. *Stirynchus.* Rostrum margined, the middle carinated; thorax behind the rostrum with two elevated abbreviated lines notched behind.
Axius Stirynchus. *Leach, Trans. Linn. Soc.* xi. 343.
Inhabits the British Sea.

### Division VI.

Gen. 54. Astacus.
*Fabr. Lam. Latr. Bosc, Penn. Leach.*

*Eyes* subglobose, not thicker than their peduncles. *Exterior antennæ*, with the first joint of the peduncle furnished with a spiniform squama that does not reach to the apex of the peduncle.

The coxæ of the third pair of legs of the female, of the fifth pair of the male, perforated. These perforations are for the passage of the semen and of the eggs, and although placed differently in other genera, yet they serve the same functions.

* *Abdomen with the sides of its segments obtuse.*

#### Astaci Marini.

Sp. 1. *Gammarus.* Rostrum on each side with four teeth, and with one on each side of its base.
Cancer gammarus. *Linn. Syst. Nat.* i. 1050.
Astacus gammarus. *Penn. Brit. Zool.* iv. 9. pl. 10.
Astacus marinus.
*Fabr. Suppl. Ent. Syst.* 406.
*Latr. Gen. Crust. et Insect.* i. 51.
Astacus gammarus.
*Leach, Edin. Encycl.* vii. 398.
—— *Trans. Linn. Soc.* xi. 344.

This species, which is the common lobster of our markets, inhabits deep clear water at the foot of rocks which hang over the sea. They breed during the early summer months, and are very prolific, Baxter having counted no less than 12,444 eggs under the abdomen. In warm weather they are very active; they have the power of springing backward in the water to a most astonishing distance into their holes in the rocks, as has been repeatedly observed by naturalists of credit. Their food consists of dead animal matter, and, it is said, also of sea-weeds. The female is stated to deposit her eggs in the sand, but the young state is not known.

The common lobster inhabits the European Ocean. It is found in very great abundance in the north of Scotland, but it is much more common on the coast of Norway, from whence the London markets are for the most part supplied.

Aristotle has very distinctly described this species under the name ἀσταχος.

** *Abdomen with the sides of its segments sharp.*

#### Astici Fluviatiles.

Sp. 1. *Fluviatilis.* Rostrum laterally dentated, the base with one tooth on each side.
Cancer astacus. *Linn. Syst. Nat.* i. 1051.
Astacus astacus.
*Penn. Brit. Zool.* iv. 18. pl. 15. fig. 27.
Astacus fluviatilis.
*Fabr. Suppl. Ent. Syst.* 406.
*Latr. Gen. Crust. et Insect.* i. 51.
*Leach, Edin. Encycl.* vii. 400.
—— *Trans. Linn. Soc.* xi. 344.

Gen. 55. Nephrops. *Leach.*

*Eyes* reniform, abruptly much thicker than their peduncles. *External antennæ* with the first joint of their peduncle furnished at its apex with a squama, which is produced beyond the apex of the peduncle.

The coxæ of the third pair of legs of the female, of the fifth pair of the male, perforated.

Sp. 1. *Norvegicus.* Abdomen with hairy areolæ; shell somewhat spiny in front.
Cancer Norwegicus. *Linn. Syst. Nat.* i. 1053.
Astacus Norwegicus.
*Penn. Brit. Zool.* iv. 17. pl. 12. fig. 24.

Inhabits the northern parts of Europe. It is found in the Frith of Forth during the summer months, often attaching itself to the lines of the fishermen. Colour, when living, flesh red. Fabricius, Bosc, and Latreille, cannot have seen this animal, as they all describe it as having four, instead of six didactyle legs.

### Division VII. *Subdivision* 1.

Gen. 56. Crangon. *Fabr. Latr. Bosc, Leach.*

*Anterior pair of legs* largest, with a compressed monodactyle hand, the rest simple; the second and third pair more slender, the fourth and fifth thicker.

Sp. 1. *Vulgaris.* Thorax behind, and on each side of the rostrum, unispinose.
Cancer crangon. *Linn. Syst. Nat.* i. 1052.
Astacus crangon. *Penn. Brit. Zool.* iv. 20.
Crangon vulgaris. *Fabr. Suppl. Ent. Syst.* 410.
*Latr. Gen. Crust. et Insect.* i. 55.
*Bosc, Hist. Nat. des Crust.* ii. 96.
*Leach, Edin. Encycl.* vii. 401. pl. 21. fig. 5.
—— *Trans. Linn. Soc.* xi. 346.

Inhabits the sandy coasts of the European Ocean, often entering estuaries, especially during the breeding season. It is the common shrimp of our markets.

Division VII. *Subdivision* 2.

Gen. 57. Atya. *Leach.*

*Four anterior legs* equal, the last joint cloven; third pair largest, unequal, with a simple claw; fourth and fifth pairs simple, terminated by a simple claw. *Tail* broad, the intermediate lamella with its extremity subacuminate, rounded.

Sp. 1. *Scabra.* Rostrum carinated trifid, the middle tooth longest; six hinder legs rough. Plate XXI.
Atya scabra. *Leach, Trans. Linn. Soc.* xi. 345.

Gen. 58. Processa. *Leach.*

*Anterior pair of legs*, with one side didactyle, the other armed with a simple claw; second pair unequal, didactyle, slender; one very long, with the wrist and fore-arm many jointed; the other shorter, with the wrist many-jointed; other legs terminated by simple claws.

Sp. 1. *Canaliculata.* Base of the rostrum with one tooth; intermediate lamella of the tail longitudinally canaliculated.
Processa canaliculata.
*Leach, Malac. Podoph. Brit.* tab. 41.

The thighs of the third and fourth pairs of legs are spinulose beneath; at the base of the rostrum there is an elevation dividing it from the thorax.

The above species, which forms the type of the genus, was discovered at Torcross, on the southern coast of Devon, by Montagu.

Division VII. *Subdivision* 3. *

Gen. 59. Pandalus. *Leach.*

*Anterior pair of legs* adactyle; second pair didactyle, unequal. *External double palpi* with the last joint of the internal footstalk longer than the preceding joint.

Sp. 1. *Annulicornis.* Rostrum ascending, many-toothed, apex notched; inferior antennæ annulated with red, and internally spinulose.
Pandalus annulicornis.
*Leach, Malac. Podoph. Britann.* tab. 40.
———, *Trans. Linn. Soc.* xi. 346.

Gen. 60. Hippolyte. *Leach.*

*Four anterior legs* didactyle. *Exteral double palpi* with the last joint of the internal footstalk shorter than the preceding joint.

Sp. 1. *Varians.* Rostrum strait, with two teeth above and below; shell above and beneath the eyes with one spine.
Hippolyte varians.
*Leach, Trans. Linn. Societ.* xi. 347.

Inhabits the rocky shores of southern Devonshire. It varies much in colour, being often found red, green, and blueish-green.

Gen. 61. Alpheus. *Fabr. Latr. Bosc, Leach.*

*Four anterior legs* didactyle. *External double palpi* with the last joint of the internal footstalk three times longer than the preceding joint.

Sp. 1. *Spinus.*
Cancer spinus. *Sowerby, Brit. Miscel.*
*Leach, Trans. Linn. Soc.* xi. 347.

Inhabits the Scottish Ocean.

Division VII. *Subdivision* 3. **

Gen. 62. Penæus. *Fabr. Latr. Bosc, Leach.*

*Six anterior legs* didactyle. *External double palpi* with five exserted joints, the last of which is obtuse.

Sp. 1. *Trisulcatus.* Thorax trisulcated behind; rostrum descending, multidentate above.
Penæus trisulcatus.
*Leach, Trans. Linn. Soc.* xi. 347.

Inhabits the Welsh Sea.

Division VII. *Subdivision* 4.

Gen. 63. Palæmon. *Fabr. Latr. Bosc, Leach.*

*Four anterior legs* didactyle; anterior pair smaller than the second pair. *External double palpi* with the last joint shorter than the preceding joint.

Sp. 1. *Serratus* (*common Prawn*). Rostrum ascending above, with from six to eight teeth, the apex emarginate; below with from four to six teeth.
Astacus serratus.
*Penn. Brit. Zool.* iv. 19. pl. 16. f. 28.
Cancer (*astacus*) squilla. *Herbst,* ii. 55. tab. 27. f. 1.
Palæmon squilla.
*Latr. Gen. Crust. et Insect.* i. 54.
*Leach, Edinb. Encycl.* vii. 401.
Palæmon serratus.
*Leach, Trans. Linn. Soc.* xi. 348.

Variety α Rostrum with six teeth above.
Subvariety 1. Rostrum beneath with four teeth.
———— 2. Rostrum beneath with five teeth.
Variety β Rostrum above with seven teeth.
Subvariety 1. Rostrum beneath with four teeth.
———— 2. ———————— five teeth.
———— 3. ———————— six teeth.
Variety γ Rostrum with eight teeth above.
Subvariety 1. Rostrum beneath with four teeth.
———— 2. ———————— five teeth.
———— 3. ———————— six teeth.

Although all the above varieties are common, yet β occurs most frequently. We have seen the upper edge of the rostrum with ten, the lower with five teeth; and both edges with but three teeth. The apex is generally notched above, but in two instances we observed the point to be entire. The situation of the teeth on the upper edge is variable, but in most instances the second tooth is at a greater distance from the first than the rest, which are generally equidistant, and rarely extend far beyond the middle, the rostrum from that part being edentate, with the exception of the emarginate apex.

Herbst, Latreille, and Dr Leach, formerly considered this species as *Cancer squilla* of Linné, but Dr L. has, since the publication of the error, met with the true *C. squilla* of that author, and has described it in the eleventh volume of the *Transactions of the Linnean Society*, p. 348.

*Palæmon serratus* of Fabricius is distinct, and, if his description be correct, it is not even referable to this Genus, he having expressly given, as its specific character ("Antennis posticis bifidis"), hinder antennæ bifid; whereas, in his generic character, he has stated these organs to be trifid ("Antennæ superiores trifidæ").

Gen. 64. Athanas. *Leach.*

*Four anterior legs* didactyle. Anterior pair larger than the second pair. *External double palpi* with the last joint longer than the preceding joint.

Sp. 1. *Nitescens.* Rostrum strait, and simple.

Crustacea.

Cancer (astacus) nitescens. *Montagu's* MSS.
Athanas nitescens.
*Leach, Trans. Linn. Soc.* xi. 349.
Inhabits the southern coast of Devonshire.

Division VIII.

Gen. 65. MYSIS.* *Latreille, Leach.*
PRAUNUS. *Leach.*

*Legs* bifid, the last joint of the four anterior pairs with the interior lacinia uniarticulate, ovate, compressed; of the other pairs of legs multiarticulate. *External double palpi* with the middle joint of the internal footstalk longest, the first very short.

At the base of the abdomen of the female is situated the external uterus, composed of two valve-like membranes, in which the young ones, just excluded from the egg, live and grow until they become strong enough to take care of themselves.

The animals of this genus swim with their head uppermost, and with their eyes spreading, which gives to them a singular and grotesque appearance.

* *Intermediate lamella of the tail emarginate.*

Sp. 1. *Spinulosa.* Tail with the intermediate lamella externally spinulose, the apex acutely emarginate; exterior lamellæ acuminate, and very broadly ciliated.
Praunus flexuosus. *Leach, Edinb. Encycl.* vii. 401.
Mysis spinulosa. *Leach, Trans. Linn. Soc.* xi. 350.
Inhabits the Frith of Forth near Leith.

Colour when alive, pellucid cinereous. Eyes black, red at their base. *Laminæ* of the external antennæ with a black longitudinal line and spots. A clouded spot on each side of the hinder part of the thorax, and another above the legs. Every segment of the body most beautifully marked with a reddish-rust-coloured spot, disposed in an arborescent form; tail fin spotted with the same colour, mixed with black. Pouch of the female with two rows of fuscous-black spots. Under side of the abdomen regularly mottled with rufous black.

It was observed with young from the middle of June to the middle of July. The females are one-third more abundant than the males. Length an inch and a quarter.

Sp. 2. *Fabricii.* Intermediate lamella of the tail obtusely notched; exterior lamellæ with rounded points.
Mysis Fabricii. *Leach, Trans. Linn. Soc.* xi. 350.
Inhabits the Greenland Sea, affording the principal sustenance of the great northern whale (Balæna mysticetus.)

** *Intermediate lamella of the tail entire.*

Sp. 3. *Integra.*
Praunus integer.
*Leach, Edinb. Encycl.* vii. 401.
Mysis integra. *Trans. Linn. Soc.* xi. 350.
Inhabits brackish pools of water left by the tide at Loch Ranza in the isle of Arran. Common in the month of August with young.

Length one-third of an inch. Females more abundant than the males. Colour whilst living pellucid, cinereous, spotted with black and reddish brown.

Crustacea.

Division IX.

Gen. 66. NEBALIA. *Leach.*

*Thorax* anteriorly with a moveable rostrum. *Anterior pair of legs* longest, simple; other pairs equal, approximate with the last joint bifid. *Antennæ* two, inserted above the eyes, the last joint bifid and multiarticulate.

Sp. 1. *Herbstii.* Gray or cinereous-yellowish; eyes black.
Cancer bipes.
*Oth. Fabr. Fn. Grön.* No. 223. fig. 2.
*Herbst*, ii. tab. 24. fig. 7.
Mysis bipes.
*Latr. Hist. Nat. des Crust. et des Insect.* vi. 285.
Monoculus rostratus.
*Montagu, Trans. Linn. Soc.* xi. 14. tab. 2. f. 5.
Nebalia Herbstii.
*Leach, Zool. Miscel.* i. 100. t. 44.
———, *Trans. Linn. Societ.* xi. 351.
Inhabits the European Ocean; it is common beneath stones lying on black mud, on the southern coast of Devon.

*Macrourous Genera of uncertain situation.*

Gen. 67. ALBUNEA.
*Dald. Fabr. Bosc, Lam. Latr. Leach.*

*Internal antennæ* with their peduncles shorter than the two setæ by which they are terminated. Legs ten, anterior pair with monodactyle hands, the thumb uncinated; hinder legs minute, spurious, filiform; the other legs terminated by a compressed sulcate joint. *Tail* not fan-shaped.

Sp. 1. *Symnista.* Shell anteriorly serrated.
Cancer symnista. *Linn. Syst. Nat.* i. 1053.
Albunea symnista.
*Fabr. Ent. Syst. Suppl.* 397.
*Latr. Gen. Crust. et Insect.* i. 44.
*Leach, Edinb. Encycl.* vii. 396.
Inhabits the Indian Ocean.

Gen. 68. REMIPES. *Latreille, Leach.*

*Internal antennæ* with their peduncles shorter than the two setæ by which they are terminated. *Legs* ten; the three hinder pairs, alike, and formed for swimming; second pair longer than the first, terminated by a conic compressed joint. *Tail* not fan-shaped.

Sp. 1. *Testudinarius.*
Remipes testudinarius.
*Latr. Gen. Crust. et Insect.* i. 45.
*Leach, Edinb. Encycl.* vii. 396.
Inhabits the New Holland Seas.

Gen. 69. HIPPA. *Fabr. Lam. Latr. Bosc, Leach.*
EMERITA. *Gronovius.*

*Internal antennæ*, with their peduncles shorter than the two setæ by which they are terminated. *Legs* ten; anterior pair adactyle, second and third pair with the last joint lunate; fourth pair with the last

* In the *Edinburgh Encyclopædia* Dr Leach gave the Genus MYSIS solely on the authority of the generally accurate Latreille, who formed the genus without any actual examination of its characters; and as he described but twelve legs, and misplaced it in the system, Dr Leach holds himself justified in having described the same Genus under the new name (PRAUNUS), which we have now rejected for that given by Latreille.

joint trigonal; hinder pair minute, filiform, spurious. *Tail* not fan-shaped.

Sp. 1. *Emeritus*. Tail inflexed, the last joint ovate.
Hippa emeritus.

*Fabr. Ent. Syst. Suppl.* 370.
*Latr. Gen. Crust. et Insect.* i. 45.
*Leach. Edinb. Encycl.* vii. 396.

Inhabits the Indian Ocean.

Gen. 70. THALASSINA. *Latreille, Leach.*

*Internal antennæ* terminated by two setæ, and inserted in the same horizontal line with the external ones. *Legs* ten, the two anterior pairs didactyle. *Tail* composed of five plates resembling a fan.

Sp. 1. *Scorpionoides*.
Thalassina scorpionoides.

*Latr. Gen. Crust. et Insect.* i. 52.
*Leach, Edinb. Encycl.* vii. 400.

Gen. 71. SQUILLA.

*Fabr. Bosc, Lam. Latr. Leach*, &c.

*Internal antennæ* with three setæ. *Legs* fourteen; anterior pair largest, monodactyle, the thumb much spined within; second, third, and fourth pairs with a monodactyle hand, the thumb being crooked and simple; the fifth, sixth, and seventh pairs spurious.

Sp. 1. *Mantis*. Body above with many elevated longitudinal lines; thumbs with six teeth.
Squilla mantis.

*Latr. Gen. Crust: et Insect.* i. 55.
*Leach, Edinb. Encycl.* vii. 402.

Inhabits the Mediterranean Sea.

Gen. 72. ZÖE. *Latr. Leach.*

ZÖEA. *Bosc.*

*Eyes* two, sessile, inserted one on each side of the head; *Rostrum* perpendicular, of the length of the thorax. *Thorax* somewhat ovate; shell diaphonous, with the back produced into a spine. *Legs* obscure and short, with the exception of the hinder ones, which are elongate, and formed for swimming. *Tail* as long as the thorax, and generally bent under it, composed of five joints, the first four very narrow, the last larger, lunate and spinulose.

Sp. 1. *Pelagica*. Spine of the back twice the length of the thorax, and bent backwards.

ZÖE Pelagica.

*Bosc, Hist. Nat. des Crust.* ii. 135. pl. 15. f. 3, 4.
*Latr. Gen. Crust. et Ins.* i. 21.
*Leach, Edin. Encycl.* vii. 389.

Inhabits the Atlantic Ocean. Was first described by Bosc in the above quoted work.

### Legion II. EDRIOPHTHALMA.

The *Malacostraca Edriophthalma*, or at least a greater part of them, were placed amongst the MACROURA by Latreille, who considered them as forming a particular family of that order. Had he examined the following new and curious genera, he would doubtless have formed a very different opinion. Many of the genera he even included amongst the Arachnides, as shall be shown hereafter.

*Synopsis and distribution of the Genera.*

#### SECTION I.

*Body laterally compressed. Legs fourteen. Antennæ two, inserted one on each side of the front of the head. (Tail furnished with styles.)*

Genus 1. PHRONYMA.

#### SECTION II.

*Body laterally compressed. Legs fourteen, with lamelliform coxæ. Antennæ four, inserted by pairs. (Tail furnished with styles.)*

Division I. Antennæ four-jointed, the last segment composed of many little joints; the upper ones very short.

Genus 2. TALITRUS.
3. ORCHESTIA.

Division II. Antennæ four-jointed, the last joint composed of several little joints; upper ones rather shortest.

Genus 4. ATYLUS.

Division III. Antennæ three-jointed, the last joint composed of several little joints; upper ones longest.

Genus 5. DEXAMINE.
6. LEUCOTHÖE.

Division IV. Antennæ four-jointed, the last segment composed of several little joints; upper ones longest.

*Subdivision* 1. Four anterior legs monodactyle, second pair with a much dilated compressed hand.

Genus 7. MELITA.
8. MÆRA.

*Subdivision* 2. Two anterior pair monodactyle and alike.

Genus 9. GAMMARUS.
10. AMPITHÖE.
11. PHERUSA.

Division V. Antennæ four-jointed, under ones longest, leg-shaped. (Four anterior legs monodactyle.)

*Subdivision* 1. Second pair of legs with a large hand.

Genus 12. PODOCERUS.
13. JASSA.

*Subdivision* 2. Second pair of legs with a moderate-sized hand.

Genus 14. COROPHIUM.

#### SECTION III.

*Body depressed. Antennæ four. Legs fourteen.*

A. *Tail without appendices.*

Division I. Body with all the segments bearing legs.

*Subdivision* 1. Body linear.

Genus 15. PROTO.
16. CAPRELLA.

*Subdivision* 2. Body broad.

Genus 17. LARUNDA.

Division II. Body with all the segments not bearing legs.

Genus 18. IDOTEA.
19. STENOSOMA.

B. *Tail on each side, with one or two appendices.*

Division III. Antennæ inserted in nearly the same horizontal line.

Genus 20. ANTHURA.

Division IV. Antennæ inserted in pairs, one above the other.

*Subdivision* 1. Tail with one lamella on each side.

Genus 21. CAMPECOPÆA.
22. NÆSA.

*Subdivision* 2. Tail with two lamellæ on each side.

* *Superior antennæ with a very large peduncle. Claws bifid.*

Genus 23. CYMODICE.
24. DYNAMENE.
25. SPHÆROMA.

** *Superior antennæ with a very large peduncle. Claws single.*

Genus 26. ÆGA.

*** *Superior antennæ with a moderate peduncle.*

Genus 27. EURYDICE.
28. LIMNORIA.
29. CYMOTHOA.

C. *Tail terminated with two setæ.*

Division V.

Genus 30. APSEUDES.

D. *Tail furnished with styles.*

Division VI. Interior antennæ distinct.

*Subdivision* 1. Styles of the tail exserted. Anterior legs monodactyle.

Genus 31. JANIRA.
32. ASELLUS.

*Subdivision* 2. Styles of the tail not exserted. Anterior legs simple.

Genus 33. JÆRA.

Division VII. Interior antennæ not distinct.

*Subdivision* 1. Styles of the tail double, with a double footstalk.

Genus 34. LIGIA.

*Subdivision* 2. Styles of the tail four, the lateral ones biarticulate.

* *Body not capable of contracting into a ball.*

*a*. External antennæ eight-jointed.

Genus 35. PHILOSCIA.
36. ONISCUS.

*b*. External antennæ with seven joints.

Genus 37. PORCELLIO.

** *Body contractile into a ball.*

Genus 38. ARMADILLO.

*Genus of uncertain situation.*

Genus 39. BOPYRUS.

SECTION I.

Gen. 1. PHRONYMA. *Latreille, Leach, Lamarck.*

*Head* large, nutant; *antennæ* biarticulate, the first joint small. Thorax seven-jointed, all its segments bearing legs. *Legs* compressed, *two anterior pairs* with the antepenultimate joint furnished at its point with a foliaceous process; the penultimate joint with the point bifid and terminated with a small claw; *third* and *fourth pairs* simple, longer, somewhat thicker, terminated by a bent claw; *fifth pair* large, very long, thicker, didactyle; the first joint gradually thickened towards its point; the second subtrigonate; the third ovate, and abruptly narrowed at its base; the last narrowed at its base; the fingers curved, and internally furnished each with one tooth; *sixth* and *seventh* pairs simple, terminated with a nearly strait claw. *Abdomen* triarticulate, each segment, on each side, with a double appendice, placed on a peduncle. *Tail* biarticulate, the first joint on each side furnished with a biarticulate process, terminated by two styles; second joint with four processes, each terminated by two styles; the inferior processes biarticulate, the superior triarticulate.

Sp. 1. *Sedentaria.* Fifth legs with the apex of the thumb and base of the finger internally denticulated.

Cancer sedentarius. *Forsk. Fn. Arab.* 95.

Phronima sedentaria.
*Latr. Gen. Crust. et Ins.* i. 57.
*Leach, Edin. Encycl.* vii. 403—433.
—— *Trans. Linn. Soc.* xi. 355.

Cancer *(gammarellus)* sedentarius.
*Herbst*, ii. 136. tab. 37. fig. 8.

Inhabits the Mediterranean Sea and Zetland Sea, residing in a cell composed of a gelatinous substance, open at each extremity, where it sits in an incurved posture.

The only specimen of this most interesting, rare, and curious animal, that has come under our inspection, was sent to us by the Reverend Dr J. Fleming, one of our most zealous Naturalists, who found it on the 3d November 1809, at Burray in Zetland, amongst rejectamenta of the sea.

All authors have erred in giving but ten legs to this animal. Of the parts of the mouth, we can, at present, say nothing.

SECTION II.

Division I.

Gen. 2. TALITRUS. *Latreille, Bosc, Leach.*

*Four anterior legs* in both sexes subequal, monodactyle. *Upper antennæ* shorter than the two first joints of the under ones.

Sp. 1. LOCUSTA. Antennæ subtestaceous-rufous, of the male longer than the body, of the female shorter; body cinereous, varied with darker cinereous.

Oniscus locusta. *Pallas?*

Talitrus locusta.
*Latr. Gen. Crust. et Insect.* i. 58.
*Bosc, Hist. Nat. des Crust.* ii. 152.
*Leach, Edin. Encycl.* vii. 402.

Astacus locusta. *Penn. Brit. Zool.* iv. 21.

Cancer *(gammarus)* saltator.
*Montagu, Trans. Linn. Soc.* xi. 94.

Inhabits the sandy shores of the European Ocean. The specific name Locusta is probably derived from the form of its protruded mouth, which has a general resemblance to the same part in the gryllides.

It has never been observed in the water; it burrows in the sand, and leaps about on the shore.

*Talitrus littoralis*, described in the seventh volume of the *Edinburgh Encyclopædia*, is merely the female of T. locusta.

The use of this animal (which is generally denominated *sand-hopper*) in the economy of nature, appears to be that of contributing to the dissolution of putrid animal and vegetable matter; serving in return as food to the shore-birds, who devour it with avidity.

Gen. 3. ORCHESTIA. *Leach.*

*Four anterior legs* of the male monodactyle, second pair with a compressed hand; of the female with the anterior pair monodactyle, the second didactyle. *Upper antennæ* not longer than the two first joints of the under ones.

Sp. 1. Littorea.

Cancer *gammarus* littoreus.
*Montagu, Trans. Soc.* xi. 96.
*Leach, Edinb. Encycl.* vii. 402. pl. 21. fig. 6.
—— *Trans. Linn. Soc.* xi. 356.

Inhabits many of our shores, and is found at the

Crustacea. mouths of rivers, but has never been observed in the water. It resides under stones and fuci, and in the evening it leaps about, and is devoured by birds.

Division II.

Gen. 4. Atylus. *Leach.*

*Upper antennæ* with the second joint longer than the third; *under ones* with the second joint somewhat shorter than the third. *Eyes* sub-prominent, rounded, inserted in a process on each side of the head, between the antennæ. *Tail* on each side with three double styles, and above with one moveable style on each side.

Sp. 1. *Carinatus.* Head with the rostrum descending; five last segments of the abdomen carinated, and acutely produced behind.

Gammarus carinatus. *Fabr. Ent. Syst.* ii. 515. 3.

Atylus carinatus.

*Leach, Zool. Miscel.* ii. 22. tab. 69.

—— *Trans. Linn. Soc.* xi. 357.

The locality is unknown.

Division III.

Gen. 5. Dexamine. *Leach.*

*Four anterior legs* sub-equal, monodactyle, furnished with a filiform-subovate hand. *Antennæ* with their first joint shortest. *Eyes* oblong, not prominent, inserted behind the superior antennæ. *Tail* on each side with three double styles, and above on each side with one moveable style.

Sp. 1. *Spinosa*, segments of the abdomen behind, produced into spines.

Cancer *(gammarus)* spinosus.

*Montagu, Trans. Linn. Soc.* xi. 3.

Dexamine spinosa.

*Leach, Edin. Encycl.* vii. 433.

—— *Zool. Miscel.* ii. 24.

—— *Trans. Linn. Soc.* xi. 359.

Inhabits the sea of the western coasts of Britain.

Gen. 6. Leucothöe. *Leach.*

*Anterior pair of legs* didactyle, the thumb biarticulate; *second pair* with a dilated and compressed hand, furnished with a crooked thumb.

Sp. 1. *Articulosa.*

Cancer articulosus.

*Montagu, Trans. Linn. Soc.* vii. 71. tab. 6. f. 6.

Leucothöe articulosa.

*Leach, Edin. Encycl.* vii. 403.

—— *Trans. Linn. Soc.* xi. 358.

Inhabits the British Sea, but is very rare.

Division IV. *Subdivision* 1.

Gen. 7. Melita. *Leach.*

*Anterior pair of legs* monodactyle; second pair with the thumb inflexed on the palm. *Tail* on each side with an elongate foliaceous lamella.

Sp. 1. *Palmata.* Body blackish; antennæ and legs annulated with pale colour.

Cancer palmatus. *Montagu, Trans. Linn. Soc.* vii. 69.

Melita palmata.

*Leach, Edin. Encycl.* vii. 403.

—— *Trans. Linn. Soc.* xi. 358.

Plate XXI.

Inhabits the sea-shore on the Devonshire coast, under stones.



Gen. 8. Mæra. *Leach.* Crustacea.

*Four anterior legs* didactyle; thumb of the second pair bent on the side of the hand. *Tail* with no foliaceous appendices.

Sp. 1. *Grossimana.*

Cancer *gammarus* grossimanus.

*Montagu, Trans. Linn. Soc.* ix. 97. t. 4. f. 5.

Mæra grossimana.

*Leach, Edin. Encycl.* vii. 403.

—— *Trans. Linn. Soc.* xi. 359.

Inhabits the southern coast of Devonshire, beneath stones.

Division IV. *Subdivision* 2.

Gen. 9. Gammarus. *Latreille, Leach.*

*Superior antennæ* furnished at the base of the fourth joint with a little jointed seta. *Tail* above with bundles of spines.

* *Tail with the superior double styles, having the upper style process very short.*

Sp. 1. *Aquaticus.* Process between the antennæ rounded, obtuse.

Gammarus pulex.

*Leach, Edin. Encycl.* vii. 402—432.

Gammarus aquaticus.

*Leach, Trans. Linn. Soc.* xi. 359.

Inhabits ponds, ditches, and springs in great plenty. We formerly considered it to be the same with the *Gammarus pulex* of Latreille and Bosc, but, on examining the subject more closely, we find their figures, are those referred to by them, representing the hands much dentated within.

Sp. 2. *Marinus.* Process between the antennæ subacuminate.

Gammarus marinus. *Leach, Trans. Linn. Soc.* xi. 359.

Inhabits the sea on the southern coast of Devonshire in plenty.

** *Tail with the superior double styles, having the style processes subequal.*

Sp. 3. *Locusta.* *Eyes* lunate.

Cancer *gammarus* locusta.

*Montagu, Trans. Linn. Soc.* ix. 92.

Gammarus locusta.

*Leach, Edin. Encycl.* vii. 403.

—— *Trans. Linn. Soc.* xi. 359.

Inhabits the British Sea.

Sp. 4. *Campylops.* Eyes flexuous.

Gammarus campylops.

*Leach, Edin. Encycl.* vii. 403.

—— *Trans. Linn. Soc.* xi. 360.

Inhabits the sea about Loch Ranza, in the Isle of Arran, where we took a single pair of this interesting animal.

Gen. 10. Ampithöe. *Leach.*

*Superior antennæ* with no seta at the base of their fourth joint. *Tail* simple above. *Hands* ovate.

Sp. 1. *Rubricata.*

Cancer *gammarus* rubricatus.

*Montagu, Trans. Linn. Soc.* ix. 99.

Gammarus rubricatus.

*Leach, Edin. Encycl.* vii. 402.

Ampithöe rubricata.

*Leach, Edin. Encycl.* vii. 432.

—— *Trans. Linn. Soc.* xi. 360.

Inhabits the sea of the southern coast of Devon.

Gen. 11. PHERUSA. *Leach.*

*Superior antennæ* with no seta at the base of their fourth joint. *Tail* simple above. *Hands* filiform.

Sp. 1. *Fucicola.* Testaceous-cinereous, or gray-cinereous, mottled with reddish.

Pherusa fucicola.

*Leach, Edin. Encycl.* vii. 432.

—— *Trans. Linn. Soc.* xi. 360.

Plate XXI.

Inhabits fuci on the southern coast of Devonshire.

Division V. *Subdivision* 1.

Gen. 12. PODOCERUS. *Leach.*

*Eyes* prominent. *Four anterior legs* mondactyle.

Sp. 1. *Variegatus.* Body varied with red and white.

Podocerus variegatus,

*Leach, Edin. Encycl.* vii. 433.

—— *Trans. Linn. Soc.* xi. 361.

Inhabits the southern coast of Devonshire, amongst confervæ and corallines.

Gen. 13. JASSA. *Leach.*

*Eyes* not prominent. *Four anterior legs* monodactyle with oval hands; second pair with its internal edge dentated.

Sp. 1. *Pulchella.* Thumb of second pair of legs with its internal edge notched at the base; colour white painted with red.

Var. α. Hands of the second pair with an elongate obtuse tooth.

Var. β. Hands of the second pair with the internal edge tridentate.

Jassa pulchella.

*Leach, Edin. Encycl.* vii. 433.

—— *Trans. Linn. Soc.* xi. 361.

Inhabits the sea of southern Devon, amongst fuci.

Division V. *Subdivision* 2.

Gen. 14. COROPHIUM. *Latreille, Leach.*

Sp. 1. *Longicorne.*

Cancer grossipes. *Linn. Syst. Nat.* i. 1055.

Astacus grossipes. *Penn. Brit. Zool.* iv. pl. 16. fig. 31.

Corophium longicorne.

*Latr. Gen. Crust. et Insect.* i. 59.

*Leach, Edin. Encycl.* vii. 403—432.

—— *Trans. Linn. Soc.* xi. 662.

Inhabits the coast of the European Ocean. At low tide, it may be observed crawling amongst the mud. It is very common at the mouth of the river Medway, from whence we have received a vast number of specimens.

SECTION III.

A. Division I. *Subdivision* 1.

Gen. 15. PROTO. *Leach.*

*Second, third, and fourth pair of legs* appendiculated at their bases.

To this genus belongs *Squilla pedata*, and probably also *Ventricosa* of Müller, with *Cancer gammarus pedatus* of Montagu, which is probably the same with *S. pedata* of Müller. See *Transactions of the Linnean Society*, Vol. XI. page 6. tab. 11. fig. 6.

Gen. 16. CAPRELLA. *Lamarck, Latr. Bosc, Leach.*

*Second, third, and fourth pairs of legs* not appendiculated at their bases; the third and fourth pairs spurious, subgelatinous, and globose.

The animals composing this genus, inhabit the sea, living amongst sertulariæ and marine plants, moving geometrically like the larvæ of the *Phalænidea.*

The specific characters may be taken from the number and situation of the spines on the head and back, form of the second pair of legs, &c.

Sp. 1. *Phasma.* Hands of the second pair of legs narrow, their internal edge acutely notched backwards: back anteriorly with three spines, turning forwards.

Cancer phasma.

*Montagu, Trans. Linn. Soc.* vii. 66. tab. 6. f. 3.

Inhabits the southern coast of Devon.

*Astacus atomos* of Pennant, and *Squilla lobata* of Müller belong to the genus Caprella, of which we have some unpublished species.

A. Division I. *Subdivision* 2.

Gen. 17. LARUNDA. *Leach.*

CYAMUS. *Latreille, Bosc.*

PANOPE. *Leach.*

*Antennæ* four-jointed, upper ones longest. *Legs* compressed, with strong claws; the third and fourth pairs elongate, spurious, cylindric, without claws; the two anterior pairs monodactyle.

External uterus, or pouch of the female, composed of four valves.

Sp. 1. *Ceti.* Bases of the third and fourth pairs of legs with processes resembling the figure 6; the hands of the second pair of legs anteriorly with three obtuse teeth. Plate XXI.

Oniscus ceti.

*Linn. Syst. Nat.* i. 1060.

*Pall. Spec. Zool.* ix. 4. f. 14.

Squille de la baleine.

*De Geer, Mém. sur les Insect.* vii. pl. 42. f. 6. 7.

Pycrogonum ceti. *Fabr. Suppl. Ent. Syst.* 570.

Cyamus ceti. *Latr. Gen. Crust. et Insect.* i. 60.

Panope ceti. *Leach, Edinb. Encycl.* vii. 404.

Larunda ceti. *Leach, Trans. Linn. Soc.* xi. 364.

Inhabits whales, and, according to Latreille, it is also found on some species of the genus Scomber.

By the Greenland fishermen it is termed the whale-louse.

Division II.

Gen. 18. IDOTEA. *Fabr. Latr. Bosc, Leach.*

ASELLUS. *Olivier, Lamarck.*

ENTOMON. *Klein.*

*External antennæ* half the length of the body, or less; the third and fourth joints equal. *Body* ovate.

Sp. 1. *Pelagica.* Body linear-oval; tail rounded, the middle with a very obsolete tooth; antennæ one third of the length of the body.

Idotea pelagica. *Leach, Trans. Linn. Soc.* xi. 365.

Inhabits the Scottish Seas.

Mr Stevenson sent us this species from the Bell-Rock, and afterwards procured for us a large log, perforated by Limnoria terebrans, which contained a vast number of them in the deserted cavities formed by that animal. It was taken in the Firth of Forth by the Rev. Dr Fleming, in whose collection there are specimens.

Colour when alive ash-gray or fuscous, speckled with darker colour, and often variegated or mottled with white spots; legs pale.

The female seems to be very rare, as amongst four hundred specimens of the animal, one only of that sex was found.

Length one inch and a quarter.

Gen. 19. STENOSOMA. *Leach.*

*External antennæ* as long as the body, the third joint, longer than the fourth. *Body* linear.

Sp. 1. *Lineare.* Last segment of the tail somewhat narrowed at its base, and dilated towards its apex, which is truncate and notched.

Oniscus linearis.
*Penn. Brit. Zool.* iv. pl. 18. fig. 2.
Idotea hectica. *Leach, Edin. Encycl.* vii. 404.
Stenosoma hecticum.
*Leach, Edin. Encycl.* vii. 433.
Stenosoma lineare.
*Leach, Trans. Linn. Soc.* xi. 366.

Inhabits the European Ocean. It sometimes occurs in the Firth of Forth, and amongst the Hebrides.

B. Division III.

Gen. 20. ANTHURA. *Leach.*

*Antennæ* short subequal, inserted one after another in the same horizontal line, the internal ones a little longest. *Body* linear. *Tail* with the last joint but one very short, the last elongate, narrower, with two elongate lamellæ on each side.

Sp. 1. *Gracilis.* Lateral processes of the tail obliquely truncated.

Oniscus gracilis.
*Montagu, Trans. Linn. Soc.* ix. tab. 5. fig. 6.
Anthura gracilis.
*Leach, Edin. Encycl.* vii. 404.
——— *Trans. Linn. Soc.* ix. 366.

B. Division IV. *Subdivision* 1.

Gen. 21. CAMPECOPEA. *Leach.*

*Tail* with its last segment furnished on each side with a compressed, curved, appendage. *Body* six-jointed, the last joint of the same size with the others. *Antennæ* setaceous, upper ones longest, their peduncle biarticulate; the space between the antennæ very great. *Anterior claws* bifid (the others I have not seen).

Sp. 1. *Hirsuta.* Brown, the last joint of the body with a few faint blueish spots.

Oniscus hirsutus.
*Montagu, Trans. Linn. Soc.* vii. t. 6. f. 8.
Campecopea hirsuta.
*Leach, Edin. Encycl.* vii. 405.
——— *Trans. Linn. Soc.* xi. 367.

Inhabits the southern coast of Devonshire; but is rather rare. Length one eighth of an inch.

Gen. 22. NÆSA. *Leach.*

*Tail* on each side of the last segment with a strait, subcompressed process attached to a peduncle. *Body* six-jointed, the last joint largest. *Antennæ* setaceous, subequal; upper ones with a very large biarticulated peduncle, the first joint largest: space between the antennæ easily to be discerned. *Claws* bifid.

Sp. 1. *Bidentata.* Last segment of the body armed with two spines or teeth: colour cinereous, faintly streaked with blue, or reddish.

Oniscus bidentatus.
*Adams, Trans. Linn. Soc.* v. 8. t. 2. f. 3.
Næsa bidentata.
*Leach, Edin. Encycl.* vii. 405.
——— *Trans. Linn. Soc.* xi. 367.

Inhabits the coasts of Wales and Devonshire.

Division IV. *Subdivision* 2. *

Gen. 23. CYMODICE. *Leach.*

*Eyes* touching the anterior margin of the first segment of the body. *Body* seven-jointed. *Tail* at the base on each side with two sub-compressed but not foliaceous appendages, the exterior ones largest; the apex of the tail notched with a lamella in the centre. *Claws* bifid.

Sp. 1. *Truncata.* Apex of the tail truncate.

Oniscus truncatus.
*Montagu's MSS.*
*Leach, Trans. Linn. Soc.* xi. 303.
——— *Edin. Encycl.* vii. 433.

This species is very rare, and has been found but three times on the southern coast of Devonshire.

Gen. 24. DYNAMENE. *Leach.*

*Eyes* not reaching to the anterior margin of the first segment of the body. *Body* seven-jointed. *Tail* with two equal foliaceous appendages on each side of its base; the apex notched. *Claws* bifid.

Dynamene.
*Leach, Edinb. Encycl.* vii. 405.
——— *Trans. Linn. Soc.* xi. 308.

Gen. 25. SPHÆROMA. *Latreille, Leach.*

*Eyes* not reaching to the anterior margin of the first segment of the body. *Body* seven-jointed. *Tail* with its apex entire; the base on each side with two equal foliaceous appendages. *Claws* bifid.

Sp. 1. *Serrata.* Body smooth, unarmed; tail very smooth on each side, obliquely truncated; lamellæ elliptic, acute, the external ones externally serrated.

Oniscus globator.
*Pall. Spec. Zool. Fasc.* ix. tab. 4. fig. 18.
Cymothea serrata. *Fabr. Ent. Syst.* ii. 510.
Sphæroma cinerea. *Latr. Gen. Crust. et Insect.* i. 65.
Sphæroma serrata.
*Leach, Edinb. Encycl.* vii. 405.
——— *Trans. Linn. Soc.* xi. 303.

B. Division IV. *Subdivision* 2. **.

Gen. 26. ÆGA. *Leach.*

*Eyes* large, granulated, oblong, oblique, marginal. *Tail* with its appendages foliaceous.

Sp. 1. *Emarginata.* Tail with the last joint acuminate; the interior lamella internally obliquely truncated, externally emarginated. Plate XXI.

Æga emarginata. *Leach, Trans. Linn. Soc.* xi. 370.

B. Division IV. *Subdivision* 2. ***.

Gen. 27. EURYDICE. *Leach.*

*Eyes* distinct, simple, lateral. *Head* as broad as the first segment of the body.

Sp. 1. *Pulchra.* Tail with the last joint semioval; body cinereous, variegated with black.

Gen. 28. LIMNORIA. *Leach.*

*Head* as broad as first segment of the body. *Eyes* granulated.

Crustacea.

Sp. 1. *Terebrans*. Body cinereous; eyes pitchy-black.
Limnoria terebrans.
*Leach, Edinb. Encycl.* vii. 433.
—— *Trans. Linn. Soc.* xi. 370.

Inhabits the British Ocean, perforating buildings of wood, piles, &c. It is common at the Bell-Rock, and on the coasts of Suffolk and Yorkshire. It generally produces seven young ones.

Gen. 29. Cymothoa. *Fabr. Dald. Leach*, &c.

*Head* narrow and small. *Eyes* obsolete. *Body* with the first segment notched to receive the head.

Sp. 1. *Œstrum*.
Cymothoa œstrum. *Fabr. Ent. Syst.* ii. 505.

C. Division V.

Gen. 30. Apseudes. *Leach*.

Sp. 1. *Talpa*. Shell anteriorly sharp, rostriform, with three excavated longitudinal lines.
Cancer *gammarus* talpa.
*Mont. Tr. Linn. Soc.* ix. t. 4. f. 6.
Apseudes talpa.
*Leach, Edinb. Encycl.* vii. 404.
—— *Trans. Linn. Soc.* xi. 372.

Inhabits the British Sea.

D. Division VI. *Subdivision* 1.

Gen. 31. Janira. *Leach*.

*Claws* bifid. *Eyes* moderate lateral-subvertical. *Internal antennæ* shorter than the peduncle of the external ones.

Sp. 1. *Maculosa*. Body cinereous, maculated with fuscous.
Oniscus maculosus. *Montagu's MSS.*
Janira maculosa.
*Leach, Edinb. Encycl.* vii. 434.
—— *Trans. Linn. Soc.* xi. 373.

Inhabits the southern coast of Devonshire, amongst marine plants.

Gen. 32. Asellus. *Geoffroy, Olivier, Latreille, Bosc, Leach.*
Entomon. *Klein.*

*Claws* simple. *Eyes* minute, lateral. *Interior antennæ* of the length of the setiferous joint of the exterior ones.

Sp. 1. *Aquaticus*. Colour cinereous, either spotted with grey or whitish.
Oniscus aquaticus.
*Linn. Syst. Nat.* i. 1061.
Aselle d'eau douce.
*Geoff. Hist. des Insect.* ii. 672. pl. 22. fig. 2.
Squille asselle.
*De Geer, Mém. sur les Insect.* vii. 496. pl. 31. fig. 1.
Aselle ordinaire.
*Latr. Hist. Nat. des Crust. et des Insect.* vi. 359.
Asellus vulgaris.
*Bosc, Hist. Nat. des Crust.* ii. 170. pl. 15. fig. 7.
*Latr. Gen. Crust. et Insect.* i. 63.
*Leach, Edin. Encycl.* vii. 404.
Idotea aquatica. *Fabr. Suppl. Ent. Syst.* 303.
Entomon hieroglyphicum. *Klein, Dub.* fig. 5.
Asellus aquaticus.
*Leach, Trans. Linn. Soc.* xi. 373.

Inhabits ponds and ditches, and is generally considered a sign of the purity of the water.

Division VI. *Subdivision* 2.

Gen. 33. Jæra. *Leach.*

*Eyes* moderately large, situated between the sides and the vertex of the head.

Sp. 1. *Albifrons*. Cinereous; front whitish.
Oniscus albifrons. *Montagu's* MSS.
Jæra alifrons.
*Leach, Edinb. Encycl.* vii. 434.
—— *Trans. Linn. Soc.* xi. 373.

Inhabits marine plants, and beneath stones, on the southern coast of Devon.

Division VII. *Subdivision* 1.

Gen. 34. Ligia.
*Fabricius, Latreille, Bosc, Leach.*

*External antennæ* with the last joint composed of several other joints.

Sp. 1. *Oceanica*. Antennæ as long as the body; back subscabrose.
Ligia oceanica.
*Fabr. Suppl. Ent. Syst.* 301.
*Leach, Edinb. Encycl.* vii. 406.
Ligia scopulorum.
*Leach, Edinb. Encycl.* vii. 406.
Oniscus oceanicus.
*Linn. Syst. Nat.* i. 1061.

Inhabits the rocky shores of the European Ocean. The last joint of the antennæ varies much in the number of its segments, even in the same individual.

Division VII. *Subdivision* 2. * *a.*

Gen. 35. Philoscia. *Latreille, Leach.*

*External antennæ* with their bases naked. *Tail* abruptly narrower than the body.

Sp. 1. *Muscorum*. Body variegated; sometimes plain brick-red.
Oniscus muscorum. *Scop. Ent. Carn.* 1145.
Oniscus sylvestris. *Fabr. Ent. Syst.* iv. 397.
Philoscia muscorum.
*Latr. Gen. Crust. et Insect.* i. 69.
*Leach, Edinb. Encycl.* vii. 406.

Inhabits France, Germany, and England, under stones and mosses.

Gen. 36. Oniscus *of authors.*

*Antennæ* inserted beneath the anterior margin of the head, on a prominent part.

Sp. 1. *Asellus*. Above obscure cinereous, rough; the sides and a series of dorsal spots yellowish.
Oniscus asellus.
*Linn. Syst. Nat.* i. 1061.
*Latr. Gen. Crust. et Insect.* i. 70.
*Leach, Edinb. Encycl.* vii. 406.
—— *Trans. Linn. Soc.* xi. 375.
Oniscus murarius.
*Fabr. Suppl. Ent. Syst.* 300.

Inhabits rotten wood and old walls throughout the greater part of Europe.

It was formerly used in medicine, and was supposed to cure agues, consumptions, &c. but has now,

Crustacea.

like many other medicines, deservedly grown out of fashion, and is rejected from the modern pharmacopœias. It is commonly named *pig's louse*, *millipied* or *carpenter*.

Division VII. *Subdivision* 2. * *b*.

Gen. 37. Porcellio. *Latreille, Leach.*

*External antennæ* inserted on a prominence under the anterior margin of the head. *Tail* with its lateral styles conic, prominulous.

Sp. 1. *Scaber*. Body rough.
Oniscus asellus.
*Fabr. Suppl. Ent. Syst.* 300.
Porcellio scaber.
*Latr. Gen. Crust. et Insect.* i. 70.
*Leach, Edinb. Encycl.* vii. 406.
—— *Trans. Linn. Soc.* xi. 37.

Division VIII. *Subdivision* 2. **

Gen. 38. Armadillo. *Latr. Leach.*

*External antennæ* seven-jointed, inserted on a prominence in a cavity on each side of the head. *Tail* with the lateral styles not prominent.

Sp. 1. *Vulgaris*. Griseous lead-coloured; hinder margin of the segments whitish.
Oniscus armadillo.
*Linn. Syst. Nat.* i. 1062.
Armadillo vulgaris.
*Latr. Gen. Crust. et Insect.* i. 70.
*Leach, Edinb. Encycl.* vii. 406.
—— *Trans. Linn. Soc.* xi. 376.

Inhabits Europe, amongst moss and under stones. It is commonly named the *pill-millified*, and paves the way to the myriapoda, in general external appearance and in economy, allied to the Genus Glomeris.

*Genus of uncertain place.*

Gen. 39. Bopyrus. *Latr.*

## Class II.—MYRIAPODA.

Myriapoda.

This Class was proposed by Dr Leach in the *Edinburgh Encyclopædia*, Vol. VII. and has since been distinctly established, and its characters more decidedly shown, in a paper published in the eleventh volume of the *Transactions of the Linnean Society*.

By Linné the animals composing this group were denominated Scolpendræ and Juli, and were arranged with apterous insects. His pupil J. C. Fabricius, in the Supplement to his *Entomologia Systematica*, placed them in a particular class named Mitosata, * comprehending all the species, like Linné, under the generic appellations of Julus and Scolpendra. G. Cuvier, in his *Tableau Elémentaire*, arranged the Myriapoda with Insects, in which he was followed by A. M. C. Duméril, who has, however, adopted the new genera proposed by Latreille.

They were arranged in the older works of Latreille along with Insects; but in his last work he has placed them in a peculiar order of the class Arachnides, which he has denominated Myriapoda; and has divided them into two families, namely,

Fam. I. Chilognatha. Gen. 1. Glomeris. 2. Julus. 3. Polydesmus. 4. Pollyxenus.

Fam. II. Syngnatha. Gen. 5. Scutigera. 6. Scolopendra.

Lamarck arranged them with the Arachnides, into three genera, 1. Scolopenda; 2 Scutigera; 3 Julus; and in his last work, he had adopted a fourth genus, Pollyxenus.

Having given a slight sketch of what has been done by systematic writers, we may observe, that we differ from them merely in considering them as constituting a distinct class, and in disposing the species under some additional generic heads, which a minute examination of their structure has most fully warranted.

*Classification.*

All the Myriapoda have their head distinct from the body, furnished with two antennæ. *Mandibles* simple, incisive. All or most of the segments of the body furnished with two or four legs.

The nervous system is composed of a series of ganglia, one in each segment of the body; these ganglia are brought into communication with each other by a longitudinal bundle of nerves, or, as it is generally, but improperly, denominated, by a spinal marrow.

The two families established by Latreille, are adopted as Orders, and his names are retained.

Order I. Chilognatha. *Maxillæ* none. *Palpi* obscure. *Lip* simple. (*Antennæ* inserted on the upper margin of the head.)

Order II. Syngnatha. Maxillæ two, distinct, with their bases united. *Palpi, maxillary* two, filiform; *labial* two terminated by a little hook.

Order I. Chilognatha. †

Fam. I. Glomeridea. *Body* contractile into a globe. *Eyes* distinct.

Gen. 1. Glomeris.

Fam. II. Julidea. *Body* not contractile into a globe. *Eyes* distinct.

Genus 2. Julus.
3. Craspedosoma.

Fam. III. Polydesmidea. *Eyes* obsolete.

Genus 4. Polydesmus.

Family I. Glomeridea.

Gen. 1. Glomeris. *Latr. Dumér. Leach.*
Armadillo. *Cuvier.*

*Antennæ* with the two first joints shortest, the sixth largest including the last, which is very small. *Body* elongate-ovate, convex above, arched beneath; first segment a little semicircular lamina, the second

* In the *Entomologia Systematica* the Genus Oniscus was included in this Class.

† The Genus Pollyxenus of Latreille we have not seen. It is figured by Geoffroy, *Hist. des Insect.* ii. pl. 59. fig. 10—12.

Myriapoda. larger than the others; the last semicircular and arched. *Legs*, sixteen pairs.

Sp. 1. *Marginata*. Black, the margins of the segments luteous or orange.

Oniscus marginatus.
*Villers, Entom.* iv. 187. tab. 11. fig. 15.
Gloméris bordé.
*Latr. Hist. Nat. des Crust. et des Insect.* vii. 66.
Oniscus marginatus.
*Oliv. Encycl. Méth. Hist. Nat.* vi. p. 24.
Julus limbatus.
*Oliv. Encycl. Méth. Hist. Nat.* vii. p. 414.
Oniscus zonatus.
*Panz. Fn. Ins. Germ. Fascic.* ix. f. 23.
Julus oniscoides.
*Townson's Tracts*, p. 151.
*Stewart, Elem. Nat. Hist.* ii. 307.
Glomeris marginata.
*Latr. Gen. Crust. et Insect.* i. 74.
*Leach, Edin. Encycl.* vii. 407.
——- *Trans. Linn. Soc.* xi.

Plate XXII.

Inhabits Britain, France, and Germany, under stones; but has generally been considered by British Naturalists as a variety of Armadillo vulgaris.

Family II. Julidea.

Gen. 2. Julus *of authors*.

*Body* serpentiform, cylindric. *Antennæ* with the second joint longer than the third. *Legs* a great many.

The British species of this obscure genus may be found described in the eleventh volume of the *Transactions of the Linnean Society*. The following species, which is the most common, will best serve as an example of the genus.

Sp. 1. *Sabulosus*. Black-cinereous, with two reddish dorsal lines; last joint mucronated; legs luteous.

Julus sabulosus.
*Linn. Syst. Nat.* i. 1065.
——*Fn. Sv.* ii. 2067.
*Fabr. Ent. Syst.* ii. 395.
*Latr. Gen. Crust. et Insect.* i. 76.
*Leach, Edinb. Encycl.* vii. 407.
——- *Trans. Linn. Soc.* xi.

Inhabits Europe, lurking beneath stones, especially in sandy places.

Gen. 3. Craspedosoma. *Leach*.

*Body* linear, depressed, the sides of the segments laterally prominent. *Antennæ* towards their extremities somewhat thicker, the second joint shorter than the third.

This genus was discovered by the late R. Rawlins, Esq., one of the most promising naturalists of this country.

* *Middle of the segments prominent.*

Sp. 1. *Raulinsii* Back fuscous-brown, with four lines of white spots; belly and legs reddish.

Craspedosoma Raulinsii.
*Leach, Edinb. Encycl.* vii. 407—434.
——- *Trans. Linn. Soc.* xi. 380.

Plate XXII.

Inhabits the neighbourhood of Edinburgh, where it occurs in some plenty under stones and amongst moss. It was first noticed by Mr Rawlins, the founder of the genus.

** *Hinder angles of the segments produced.*

Sp. 2. *Polydesmoides*. Body reddish-gray; belly pale; legs reddish, with their bases pale; produced angles of the body each furnished with a seta. Myriapoda.

Julus polydesmoides. *Montagu's* MSS.
Craspedosoma polydesmoides.
*Leach, Edinb. Encycl.* vii. 407—434.
——- *Trans. Linn. Soc.* xi. 380.

Plate XXII.

Inhabits Devonshire, under stones. It is common all along the borders of Dartmoor, and on the southern coast.

Family III. Polydesmidea.

Gen. 4. Polydesmus. *Latr. Dumér. Leach.*

*Antennæ* with the second joint scarcely longer than the first, and much shorter than the third. *Body* linear, the segments laterally compressed, margined. *Eyes* obsolete.

Sp. 1. *Complanatus*. Reddish cinereous, last segment of the body mucronated.

Julus complanatus.
*Linn. Syst. Nat.* i. 1065.
*Fabr. Ent. Syst.* ii, 393.
Polydesmus complanatus.
*Latr. Gen. Crust. et Insect.* i. 76.
*Leach, Edinb. Encycl.* vii. 408.
——- *Trans. Linn. Soc.* xi. 381.

Plate XXII.

Inhabits Europe, under stones.

Order II Syngnatha.

Fam. I. Cermatidea. *Body* with the segments each bearing four legs.

Genus 1. Cermatia.

Fam. II Scolopendridea. *Body* with each segment bearing two legs: *hinder legs* distinctly longer than the others.

Stirps 1. Legs on each side fifteen.

Genus 2 Lithobius.

Stirps 2. Legs on each side twenty-one.

Genus 3. Scolopendra.

——- 4 Cryptops.

Family III. Geophilidea. *Body* with each segment bearing two legs: hinder legs not distinctly longer than the others *Legs* many, varying in number in the same species.

Genus 5 Geophilus.

Family I Cermatidea.

Genus 1. Cermatia. *Illiger, Leach.*

Scutigera. *Lam. Latr. Dumér. Leach.*

*Legs* thirty

Sp 1. *Coleoptrata*. Body reddish-yellowish, with longitudinal lines and bars on the legs of blue black.

Scolopendra coleoptrata.
*Linn. Syst. Nat.* i. 1062.
*Fabr. Ent. Syst* ii. 389
Julus araneöides. *Pall. Spec. Zool. Fas.* ix. t. 4. f. 16.
Scutigera araneöides.
*Latr. Gen. Crust. et Insect.* i. 77.
Scutigera coleoptrata.
*Leach, Edinb. Encycl.* vii. 408.

Inhabits houses in the south of Europe. It is common also in Africa.

Family II. Scolopendridea.

Gen. 2. Lithobius. *Leach.*

*Antennæ* conic-setaceous (joints about forty-five), conic-setaceous, the two first joints largest. *Under*

*lip* anteriorly broadly notched, the margin very much denticulated. *Eyes* granulated.

Sp. 1. *Forpicatus.* Head broad; under lip entirely and deeply covered with impressed dots; legs testaceous-yellowish.

Scolopendra forpicata.

*Linn. Syst. Nat.* i. 1062.

*Fabr. Ent. Syst.* ii. 390.

Lithobius forpicatus.

*Leach, Edinb. Encycl.* vii. 408.

—— *Trans. Linn. Soc.* xi. 381.

Plate XXII.

Inhabits Europe, beneath stones.

The other species are described in the eleventh volume of the *Transactions of the Linnean Society of London.*

Gen. 3. Scolopendra *of authors.*

*Antennæ* conic-setaceous, composed of (seventeen subconic joints. *Mouth* covered by hemispheric galeæ. *Exterior palpi* with a double footstalk; the last joint internally compressed, and armed with two claws. *Mandibles* strong, corneous, without teeth. *Under lip* divided by a fissure, the anterior margin narrower, strait and denticulated. *Body* with the segments margined. *Anterior pair of legs* small, the *last pair* largest, with the inner edge of the first joint spinose. *Eyes* eight, four on each side of the anterior margin of the head, arranged in a rhomboidal form.

Of this genus we have no indigenous species. The genus contains several species which have been confounded together under the title of Scolopendra morsitans, to which the generic instead of the specific character has been applied.

* *Body with the segments nearly of equal size.*

Sp. 1. *Gigas.* Segments transversely-quadrate, with rounded angles, of ferruginous brown colour, luteous behind; antennæ, palpi, galeæ, and legs testaceous; legs (anterior pair excepted) with the first (and rarely the second) joint spinulose.

Scolopendra gigas. *Leach, Trans. Linn. Soc.* xi.

Locality unknown.

Fine specimens of this species are preserved in the cabinet of Professor Jameson of Edinburgh, and in the British Museum.

** *Body with the segments transverse, alternately longer and shorter; the fifth and sixth subequal.*

Sp. 2. *Alternans.* Hinder legs with the first joint rounded, and internally spinulose.

Scolopendra alternans.

*Leach, Trans. Linn. Soc.* xi. 383.

Plate XXII.

Locality unknown.

Sp. 3. *Subspinipes.* Hinder legs with the first joint subrounded, flat above, at the internal apex subspinose.

Scolopendra subspinosa.

*Leach, Trans. Linn. Soc.* xi.

Locality unknown.

British Museum.

Sp. 4. *Trigonopoda.* Hinder legs trigonate, the first joint above and below internally spiniferous.

Scolopendra trigonopoda.

*Leach, Trans. Linn. Soc.* xi.

Locality unknown.

British Museum.

*** *Segments of the body elongate, or subelongate, irregular, now longer, then shorter.*

Sp. 5. *Morsitans.*

Scolopendra morsitans *of authors.*

Inhabits India.

Gen. 4. Cryptops. *Leach.*

*Antennæ* conic-setaceous, composed of (seventeen) globose-subconic joints. *Under lip* not denticulated, anterior margin scarcely emarginate. *Hinder legs* with the first joint toothless. *Eyes* obscure.

Sp. 1. *Hortensis.* Testaceous-ferruginous; back deeper in colour; antennæ and legs hairy.

Scolopendra hortensis.

*Donovan, Brit. Ins.*

Cryptops hortensis.

*Leach, Edinb. Encycl.* vii. 408.

—— *Trans. Linn. Soc.* xi.

Plate XXII.

Inhabits gardens in and near Exeter. It has likewise been found near Plymouth, in Devonshire.

Family III. Geophilides.

Gen. 5. Geophilus. *Leach.*

*Eyes* obscure. (*Lip* divided by a fissure?) *Mandibles* strong. *Antennæ* cylindric in some, towards the apex gradually somewhat narrower in others; composed of (fourteen) subcylindric joints, a little narrower at their base.

* *Antennæ with short joints.*

Sp. 1. *Carpophagus.* Head, antennæ, and arms fulvescent; body violet, anteriorly yellowish; legs pale yellowish.

Var. B. Body obscurely subviolet-testaceous, anteriorly subtestaceous.

Geophilus carpophagus.

*Leach, Trans. Linn. Soc.* xi. 384.

Inhabits Devonshire, in garden fruit; it is not uncommon.

Sp. 2. *Subterraneus.* Body yellow, head subferruginous.

Scolopendra subterranea.

*Shaw, Trans. Linn. Soc.* ii. 7.

Geophilus subterraneus.

*Leach, Trans. Linn. Soc.* xi. 385.

Inhabits the earth. Is very common in England.

Sp. 3. *Acuminatus.* Body ferruginous, anteriorly gradually narrower; head anteriorly and the legs paler.

Geophilus acuminatus.

*Leach, Trans. Linn. Soc.* xi. 386.

Inhabits moss and beneath the ground. It is rare.

** *Antennæ with elongate joints.*

Sp. 4. *Longicornis.* Body yellow; head ferruginous; antennæ long.

Geophilus longicornis.

*Leach, Trans. Linn. Soc.* xi. 386.

Plate XXII.

Inhabits the earth and under stones.

Obs. Scolopendra electrica of Linné, belongs to this genus.

## Class III.—ARACHNIDES.

From *αραχνη*, a *spider*, and *ειδος*, *resemblance*; a class of animals formerly arranged with insects, but first shown to be distinct by the celebrated Lamarck, and established as such, by Latreille and Cuvier.

Of the history of the Arachnides little can be said; we shall therefore content ourselves with giving a general view of the ideas entertained by authors. Linné arranged all of these animals with which he was acquainted with apterous insects, under the generic titles, Phalangium, Aranea, Acarus and Scorpio; and in this disposition he was followed by Cuvier.

Lamarck, in his *Systême des Animaux sans Vertébres*, has included amongst the Arachnides, the Myriapoda, and certain animals which we have considered as forming a subclass of insects, as shall be hereafter mentioned; and he has disposed what we consider as genuine Arachnides, into two divisions.

I. *Mouth furnished with mandibles and with maxillæ.*

Genus 1. Scorpio, 2. Aranea, 3. Phrynus, 4. Galeodes, 5. Phalangium, 6. Chelifer, 7. Elaïs, 8. Trombidium.

II. *Mouth furnished with a rostrum or haustellum.*

Genus 9. Hydrachna, 10. Bdella, 11. Acarus, 12. Pycnogonum, 13. Nymphum.

Duméril, in his *Zoologie Analytique*, has placed the Arachnides with the apterous insects. He arranges the genus, 1. Ixodes, *Latr.* with Pediculus and Pulex; the other genera he has placed in a peculiar family; 2. Aranea, 3. Mygale, 4. Phrynus, 5. Scorpio, 6. Chelifer, 7. Galeodes, 8. Phalangium.

Lamarck, in his *Extrait du Cours*, &c. has placed the Arachnides with some genuine insects and Myriapoda, but he has formed for them a separate order, which he terms Arachnides palpati, and disposes them into the following little groups of genera.

I. Pycnogonides.

Genus 1. Nymphum, 2. Phoxichilus, 3. Pycnogonum.

II. Acarides.

* *Parasiticæ.*

a. *Six legs.*

Genus 4. Astoma, 5. Leptus, 6. Caris.

b. *Eight legs.*

Genus 7. Uropoda, 8. Argas, 9. Ixodes, 10. Acarus.

** *Vagebundæ.*

a. *Land.*

Genus 11. Oribata, 12. Smaris, 13. Cheyletus, 14. Bdella, 15. Erythræus, 16. Trombidium.

b. *Aquatic.*

Genus 17. Elais, 18. Limnocharis, 19. Hydrachna.

III. Phalangides.

Genus 20. Siro, 21. Trogulus, 22. Phalangium, 23. Galeodes.

IV. Scorpionides.

Genus 24. Chelifer, 25. Scorpio, 26. Thelephonus, 27. Phrynus.

V. Araneides.

Genus 28. Aranea, 29. Mygale.

*Classification.*

The following classification is that lately published in the eleventh volume of the *Transactions of the Linnean Society*. It may not be improper to observe, that, from the Arachnides of Latreille, we have not only removed the *Tetracera* and *Myriapoda* (the first being referable to the *Crustacea*, the second to a new class), but also the *Parasita* and *Thysanura*, which form a subclass of genuine insects, and have added to the Arachnides the genus *Nycteribia*, which agrees with them in general structure.

Subclass I. Cephalostomata. Mouth situated in the front of the head.

Subclass II. Notostomata. Mouth situated on the back.

### Subclass I. CEPHALOSTOMATA.

A. *Legs with coxæ, thighs, tibiæ, and tarsi, distinct in form.*

Order I. Podosomata. *Body* four-jointed, and formed as it were of the junction of the coxæ. *Mouth* tubular. *Eyes* four, placed on a common tubercle. *Legs* eight.

Order II. Polymerosomata. *Body* composed of a series of segments; abdomen not pedunculated. *Mouth* furnished with didactyle mandibles and with maxillæ. *Eyes* two, four, six, or eight. Legs eight.

Order III. Duomerosomata. *Body* composed of two segments, the abdomen pedunculated. *Mouth* furnished with mandibles, and with maxillæ. *Eyes* six or eight. *Legs* eight.

B. *Legs, with the coxæ, thighs, tibiæ, and tarsi, not distinct from each other in form.*

Order IV. Monomerosomata. *Body* formed but of one segment. *Mouth* rostriform, or in some furnished with maxillæ and mandibles. *Legs* eight or six.

### Order I. Podosomata.

The singular animals which compose this order inhabit the sea. The females are furnished with two palpiform organs inserted at the base of the rostrum, on which parts they carry their eggs, attached in globular masses.

The legs are composed of three-jointed coxæ, one-jointed thighs, two-jointed tibiæ and tarsi, the latter parts furnished with claws.

Family I. Pycnogonideæ. *Mandibles* none.

Genus 1. Pycnogonum.

2. Phoxichilus.

Family II. Nymphonideæ. *Mandibles* two, biarticulate, didactyle.

Genus 3. Ammothea.

4. Nymphum.

Family I. Pycnogonideæ.

Gen. 1. Pycnogonum *of authors.*

*Legs* rather strong; coxæ with subequal joints; tibiæ with the first joint largest; tarsi with the first joint very small; claws simple, strong, acute.

*Egg-bearing organs* ten-jointed, the last joint very acute, unguiform, attached to the first joint of the body at the base of the rostrum.

Sp. 1. *Balænarum.* Plate XXIII.

Arachnides. Pycnogonum balænarum.

*Fabr. Ent. Syst.* iv. 416.
*Latr. Gen. Crust. et Insect.* i. 144.
*Leach, Edin. Encycl.* vii. 413. pl. 221. fig. 2.
—— *Trans. Linn. Soc.* xi. 388.

Inhabits the European Ocean. It is not uncommon in the Plymouth Sound, where it is taken by the trawl-fishers.

Gen. 2. Phoxichilus. *Latr. Leach.*

*Legs* very slender; *coxæ* with the middle joint longest, subclavate; *tibiæ* with the first joint shorter; *tarsi* with the first joint very small; claws double, unequal, the longer one acute.

*Egg-bearing organs* seven-jointed, the last joint tuberculiform, inserted at the base of the rostrum, one on each side, and attached to the first segment of the body.

The specific characters of none of the species are yet ascertained. To the genus, however, belong Pycnogonum spinipes, *Oth. Fabr. Fn. Grœn.* 232. and Phalangium hirsutum, *Montagu, Trans. Linn. Soc.* ix. tab. 5. fig. 7.

Family II. Nymphonideæ.

Gen. 3. Ammothea. *Leach.*

*Mandibles* much shorter than the rostrum, with equal joints, the fingers arcuate, and meeting at their tips. *Palpi* nine-jointed, the third joint very long. *Legs* slender; *coxæ* with the middle joint longest; *tibiæ* with the first joint somewhat shortest; *tarsi* with the first joint small; *claws* double, unequal.

*Egg-bearing organs* nine-jointed, inserted under the first legs, behind the rostrum.

Sp. 1. *Carolinensis.* Body entirely brown, testaceous; back with three trigonate tubercles.

Ammothea Carolinensis.

*Leach, Zool. Miscel.* i. 34. tab. 13.
—— *Trans. Linn. Soc.* xi.

Plate XXIII.

Inhabits the sea about Southern Carolina.

Gen. 4. Nymphum. *Lamarck, Leach.*
Nymphon. *Fabricius, Latreille.*
Pycnogonum. *Müller.*

*Mandibles* longer than the rostrum, with equal joints, the fingers curved, meeting along their whole length, and abruptly hooked at their extremities. *Palpi* six-jointed, the second joint elongate, the sixth very small. *Legs* very slender, coxæ with the middle joint longest; tibiæ with the second joint rather longest; tarsi with the first joint somewhat shortest, claws simple.

*Egg-bearing organs* ten-jointed, inserted behind the rostrum, almost under the anterior pair of legs.

Sp. 1. *Gracile.* Cinereous, thighs cylindric.

Nymphum gracile.

*Leach, Zool. Miscel.* i. 45. tab. 19. fig. 1.

Plate XXIII.

Inhabits the British seas everywhere; but as it never attains the size of the *phalangium,* misnamed by Linné *grossipes* (which is figured by Ström in his history of Sondmor, 208. tab. 2. fig. 16.), we are doubtful if it be the same species; but as the Linnean name is so ridiculously inapplicable, little fault can be found with the more appropriate name for which it has been exchanged.

Sp. 2. *Femoratum.* Reddish, thighs dilated and compressed.

Nymphum femoratum.

*Leach, Zool. Miscel.* i. 45. tab. 19. fig. 2.

Inhabits the shores on the southern coast of Devon.

Order II. Polymerosomata.

Fam. I. Sironeæ. *Palpi* simple. *Mandibles* didactyle.

Genus 5. Siro.

Fam. II. Scorpionideæ. *Palpi* arm-shaped. *Mandibles* didactyle. *Legs* alike.

*Stirps* 1. *Tail* none. *Eyes* two or four. *Pecten* none.

Genus 6. Obisium.
7. Chelifer.

*Stirps* 2. *Tail* elongate, articulated, terminated by a curved sting. *Eyes* six or eight. *Pecten* one on each side of the base of the abdomen.

Genus 8. Scorpio.
9. Buthus.

Fam. III. Tarantulideæ. *Mandibles* monodactyle. *Palpi* arm-shaped. *Anterior* legs shaped like antennæ; six hinder ones alike, simple. *Eyes* eight.

*Stirps* 1. *Tail* filiform. *Palpi* didactyle.

Genus 10. Thlephonus.

*Stirps* 2. *Tail* none. *Palpi* terminated by a moveable hook.

Genus 11. Tarantula.

Family I. Sironeæ.

Gen. 5. Siro. *Latreille, Leach.*

*Mandibles* two, two-jointed, cylindric, compressed, their points armed with a forceps. *Palpi* two, five-jointed, joints elongate, the second longest. *Body* oval. *Eyes* two, placed one in each side of the thorax, on an erect peduncle. *Legs* elongate, filiform; tibiæ and tarsi two-jointed, the latter parts terminated by an arcuate claw.

Sp. 1. *Rubens.* Pale red, legs paler.

Siro rubens.

*Latr. Gen. Crust. et Insect.* i. 143.
*Leach, Edinb. Encycl.* vii. 416.
—— *Trans. Linn. Soc.* xi. 390.

Plate XXIII.

Inhabits moss at the roots of trees and in woods.

Family II. Scorpionideæ.

The animals composing this fami y constitute a most natural group.

*Stirps* 1.

Gen. 6. Obisium. *Illiger, Leach.*

*Body* cylindric. *Thorax* composed of one segment. *Mandibles* porrect. *Eyes* four.

Sp. 1. *Trombidioides.* Second joint of the arms elongate; fingers long and strait.

Chelifer Trombidioides.

*Latr. Gen. Crust. et Insect.* i. 133.

Obisium Trombidioides.

*Leach, Edinb. Encycl.* vii. 428.
—— *Trans. Linn. Soc.* xi. 391.

Plate XXIII.

Inhabits France and England, under stones.

Gen. 7. Chelifer. *Geoffroy, Leach.*

*Thorax* composed of three parts. *Mandibles* short. *Eyes* two.

Sp. 1. *Fasciatus.* Hands oval; segments of the abdomen bordered with whitish.

Chelifer fasciatus. *Leach, Trans. Linn. Soc.* ix.

Inhabits beneath the bark of willow and other trees.

Arachnides. It sometimes occurs near London. It is mentioned by Geoffroy (*Hist. des Insect.* ii. 618.)

Plate XXIII.

*Stirps* 2.

Gen. 8. SCORPIO *of authors.*

Eyes six.

Sp. 1. *Europæus.* Pecten with nine teeth; hands angulated, subcordate; wrists unidentate; body obscure brown; legs and last joint of the tail brownish-yellow.

Scorpio Europæus.

*Villers, Entom.* iv. 131. tab. 2. f. 11.
*Latr. Gen. Crust. et Insect.* i. 131.
*Leach, Edinb. Encycl.* vii. 429.
——— *Trans. Linn. Soc.* xi. 391.

Inhabits the south of Europe.

Gen. 9. BUTHUS. *Leach.*

Eyes eight.

Sp. 1. *Occitanus.* Pecten with twenty-eight teeth; body yellowish; tail longer than the body, with elevated granulated lines; no point beneath the sting.

Scorpio occitanus.

*Amoreaux, Jour. de Phys.* an. 1789.
*Latr. Gen. Crust. et Ins.* i. 132.
*Leach, Edinb. Encycl.* vii. 428.

Buthus occitanus. *Leach, Trans. Linn. Soc.* xi. 391.

Inhabits southern Europe; it occurs in France and in Portugal.

Family III. TARANTULIDEÆ.

*Stirps* 1.

Gen. 10. THELYPHONUS. *Latreille, Leach.*

*Maxillæ* subtriangular, large, meeting within. *Palpi* very thick, terminated by a didactyle hand.

*Body* elongate. *Thorax* ovate, with two eyes on its anterior margin towards the middle, and three on each side, placed in a triangle.

Sp. 1. *Proscorpio.*

Phalangium caudatum. *Linn. Syst. Nat.* i. 1029.
Tarantula caudata. *Fabr. Ent. Syst.* ii. 433.
Thelyphonus proscorpio.

*Latr. Gen. Crust. et Ins.* i. 130.
*Leach, Edinb. Encycl.* vii. 428.
——— *Trans. Linn. Soc.* xi.

Inhabits Southern America.

*Stirps* 2.

Gen. 11. TARANTULA. *Brown, Fabricius, Leach.*

PHRYNUS. *Olivier, Lam. Fabr. Hermann.*

*Maxillæ* obverse-conic, divergent; internal apex produced, compressed, and rounded. *Palpi* terminated by a moveable, horny, bent claw.

*Body* depressed. *Thorax* broad, reniform, or lunate, with two eyes about the middle of its anterior margin, and three on each side, placed in a triangle.

Sp. 1. *Lunata.* Palpi nearly three times the length of the body; apex of the third joint with four spines, the two upper ones strongest.

Tarantula lunata.

*Fab. Ent. Syst.* ii. 433.
*Leach, Edin. Encycl.* vii. 428.
——— *Trans. Linn. Soc.* xi. 392.

Phrynus lunatus. *Latr. Gen. Crust. et Insect.* i. 128.

Inhabits the East Indies.

Order III. DUOMEROSOMATA.

Fam. I. SOLPUGIDEÆ. *Eyes* four. *Anus* simple.

Genus 12. SOLPUGA. Arachnides.

Fam. II. PHALANGIDEÆ. *Eyes* two. *Anus* simple.

Genus 13. PHALANGIUM.
14. OPILIO.

Fam. III. ARANEIDEÆ. *Eyes* six or eight. *Anus* with nipples for spinning.

*Stirps* 1. *Legs* simple. *Hinder* eyes not placed on the anterior and superior part of the thorax, nor forming an irregular hexagon. *The two exterior nipples* of the anus longer than the others, and projecting. *Lip* not advancing between the maxillæ nor prominent, but as long as broad.

* *Eyes eight. Mandibles projecting.*

Genus 15. MYGALE.
16. ATYPUS.
17. ERIODON.

** *Mandibles perpendicular. Eyes six.*

Genus 18. SEGESTRIA.
19. DYSDERA.

*** *Mandibles perpendicular. Eyes eight.*

Genus 20. FILISTATA.
21. DRASSUS.
22. CLOTHO.
23. CLUBIONA.
24. ARANEA.
25. AGELENA.
26. ARGYRONETA.

*Stirps* 2. *Legs* simple. *Hinder eyes* not placed on the anterior and superior of the thorax, nor forming an irregular hexagon. *Nipples* of the anus short and nearly equal, of a conic form. *Lip* nearly semicircular, broader than long, and projecting between the maxillæ. (*Eyes* eight).

* *Eyes not describing the segment of a circle. Maxillæ straightened towards their extremities, but not dilated.*

Genus 27. SYCTODES.
28. THERIDION.
29. LATRODECTUS.
30. PHOLCUS.

** *Eyes not describing the segment of a circle. Maxillæ strait with their points dilated.*

Genus 31. ULOBORUS.
32. TETRAGNATHA.
33. LINYPHIA.
34. EPEIRA.
35. NEPHILA.

*** *Eyes describing the segment of a circle.*

Genus 36. EPISENUS.
37. MICROMMATA.
38. THOMISUS.

*Stirps* 3. *Legs* not formed for leaping. *Hinder eyes* placed on the anterior and superior part of the thorax, forming an irregular hexagon.

* *Anterior legs longest.*

Genus 39. OXYOPES.
40. STORENA.
41. CTENUS.

** *Hinder pair of legs longest.*

Genus 42. LYCOSA.
43. DOLOMEDES.

*Stirps* 4. *Legs* formed for leaping. (*Eyes* eight. *Thorax* never carinated).

Genus 44. ERESUS.

Genus 45. SALTICUS.

46. ATTUS.

Family I. SOLPUGIDEÆ.

Gen. 12. SOLPUGIDEÆ.

*Lichtenst. Fabr. Herbst, Leach.*

GALEODES. *Olivier, Lamarck, Latreille.*

RHAX. *Bermann.*

*Eyes* placed on a common tubercle. *Mandibles* very large, strait. *Palpi* very large, formed like legs, the last joint simple. *Body* elongate.

Sp. 1. *Arachnoides.* Pale-yellowish, mixed with cinereous.

Solpuga arachnoides.

*Lichtenst. Catal. Hamb.* 1797, 151, 196.

Solpuga araneoides.

*Fabr. Suppl. Ent. Syst.* 294.

Galeodes araneoides.

*Oliv. Encycl. Méth. Hist. Nat.* vi. 590.

*Latr. Gen. Crust. et Insect.* i. 135.

Inhabits the Cape of Good Hope.

Family II. PHALANGIDEÆ.

Gen. 13. PHALANGIUM of authors.

*Eyes* placed in a common peduncle. *Mandibles* corneous, subcylindric, compressed, biarticulate, inflexed or geniculated at the second joint, the apex of which bears a forceps with equal fingers. *Palpi* formed like legs terminated by a hook. *Body* more or less oval. *Second pair of legs* almost six times the length of the body; *tarsi* all capillary, very slender, the first joints elongate, four times (or more) longer than broad.

Sp. 1. *Opilio. Latr. Gen. Crust. et Insect.* i. 157.

Male, Phalangium cornutum.

*Linn. Syst. Nat.* i. 1028.

*Fabr. Ent. Syst.* ii. 430.

Female, Phalangium opilio.

*Linn. Syst. Nat.* i. 1027.

*Fabr. Ent. Syst.* ii. 429.

Inhabits Europe, on walls and rocks.

Gen. 14. OPILIO.

*Eyes* placed on a common peduncle. *Mandibles* corneous, subcylindric, compressed, biarticulate, inflexed or geniculated at the second joint, the apex of which has a forceps with equal fingers. *Palpi* formed like legs, terminated by a hook. *Body* more or less oval. *Second pair of legs* three or four times the length of the body, the fourth and following joints a little elongate, twice as long as broad.

Sp. 1. *Histrix.*

Phalangium histrix.

*Latr. Gen. Crust. et Insect.* i. 140.

Inhabits France and England.

Family III. ARANEIDEÆ.

The animals composing this most natural family, are familiarly denominated spiders, and, as we have before mentioned, were included by Linné, Fabricius, and other authors, in one genus, which they called Aranea; but as the species are very numerous, they were obliged to divide them into sections, which they distinguished by the situation of their eyes. These organs are immoveable, and consist each of a single lens, which deprives them of the faculty of seeing in every direction.

The Araneideæ are by far the most interesting animals of that class of which they form the type; and consequently their habits and structure excited the attention of naturalists at a very early period.



Aristotle and Pliny were acquainted with those species that have the power of darting out long threads. *Vide Aristotelis Historia Animalium*, lib. ix. cap. 89. and *Plinii Hist. Naturalis*, lib. xii. cap. 74.

Spiders frequently change their skins, and their skins are often found in their webs, being dry and transparent, with their mandibles attached to them. When about to cast their covering, they suspend themselves in some corner, and creep out of a crack which takes place on their back, gradually withdrawing their legs from the skin, as if from a glove. They have likewise the power of reproducing their legs; the mode in which this takes place, was made known to us by Sir Joseph Banks, and which we shall relate as nearly as possible in the words of that accurate observer of nature.

As he was writing one evening in his study, one of the web-spinning spiders, of more than the middle size, passed over some papers on the table, holding a fly in its mouth. Much surprised to see a spider of this description walking about with its prey, and being struck with somewhat unusual in its gait, he caught it and placed it within a glass for examination; when instead of eight, he perceived that it had but three legs, which accounted for the inability of the creature to spin its web; but the curious circumstance of its having changed its usual economy, and having become a hunting instead of a spinning spider, as well as a wish to learn whether its legs would be renewed, induced him to keep the animal in the glass, from whence it could not escape, and to observe its conduct.

On the following morning the animal eat two flies, given to it, by sucking out the juices, but left the carcasses entire. Two or three days afterwards, it devoured the body and head of a fly, leaving only the wings and legs. After this time, it sometimes sucked and sometimes eat the fly given to it. At first it consumed two flies in a day, but afterwards not more than one in two days. Its excrement, which it voided, was at first of a milky-white colour, but afterwards the white had a black spot in the centre, of a more solid appearance than the surrounding fluid.

Soon after its confinement, it attempted to form a web on the side of the vessel, but performed the business very slowly and clumsily, from the want of the proper number of legs. In about a fortnight it had completed a small web, upon which it generally sat.

A month after having been caught, it shed its skin, leaving the slough on the web. After this change five new legs appeared, not half as long as the other three legs, and of very little use to the animal in walking. These new members, however, extended themselves a little in three days, and became half as long as the old ones. The web was now increased, and the animal continued immoveably sitting on it in the day time, unless drawn from it, or attracted by a fly thrown to it as its usual provision.

Twenty-nine days afterwards, it again lost its skin, leaving the slough hanging in the web, opposite to a hollow cell it had woven, so as to prevent it from

being completely seen when lodged in it. The legs were now larger than before the change of skin, and they grew somewhat longer still in three or four days, but did not attain the size of the old legs.

The animal now increased its web, and being put into a small bowl, as a more commodious residence, soon renewed a better web than the first. In this state it was left on the first of November. No farther observations have yet been made on the subject.

The principal use of the *Aranëideæ*, in the economy of nature, seems to be that of preventing the too great increase of insects.

The palpi of the different sexes should be carefully described, as they seem to afford some most excellent subsidiary generic characters.

*Stirps* 1. *

Gen. 15. Mygale. *Walckanäer, Latreille, Leach.*

*Labium* very small and quadrate, inserted under the base of the maxillæ. *Palpi* attached to the apex of the jaws. *Eyes* on each side geminated.

A. *Claws of the tarsi, with a few very obscure, or with no denticulations beneath.*

* *Last joint of the tarsi and palpi with a brush of hair.*

Sp. 1. *Avicularia.* (Bird-catching Mygale). Blackish, very hairy, the hairs elongate: palpi and legs with ferruginous tips; tarsi broad; claws not exserted. (*Palpi* of the male globose, produced into a very long, very slender hook).

Aranea avicularia.
*Linn. Syst. Nat.* i. 1034.
*Fabr. Ent. Syst.* ii. 424.

Mygale avicularia.
*Latr. Gen. Crust. et Insect.* i. 83.
*Leach, Edin. Encycl.* vii. 420.

Inhabits South America.

** *Palpi and tarsi without any brush.*

Sp. 2. *Cæmentaria.* Ferruginous brown; mandibles blackish; carina and margin of the thorax paler.

Mygale cæmentaria.
*Latr. Gen. Crust. et Insect.* i. 84.
*Leach, Edin. Encycl.* vii. 421.

Inhabits the South of France. It is described by Dorthes in the second volume of the *Transactions of the Linnean Society*, tab. 17. fig. 6.

B. *Claws of the tarsi internally much dentated.*

Sp. 3. *Calpeiana.*

Mygale calpeina.
*Walck. Tab. des Aran.* 5.
*Latr. Gen. Crust. et Insect.* i. 85.
*Leach, Edin. Encycl.* vii. 421.

Gen. 16. Atypus. *Latreille, Leach.*

Oletera. *Walckanäer.*

*Eyes* on each side geminated. *Lip* very small and quadrate, inserted under the base of the maxillæ. *Palpi* inserted at the external base of the maxillæ, which are dilated at that part.

Sp. 1. *Sulzeri.* Black and shining; mandibles very long and strong; thorax nearly quadrate; plain behind, abruptly elevated before; the two middle eyes placed on an eminence; back of the abdomen coriaceous and more shining; joints of the legs whitish.

Atypus.
*Latr. Nouv. Diction. d'Hist. Nat.* tab. 24. p. 133.

Atypus sulzer.
*Latr. Gen. Crust. et Insect.* i. 85.
*Leach, Edin. Encycl.* vii. 421.

Oletère dittorme. *Walck. Tab. des Aran.* 7.

Plate XXIII.

Inhabits France and England. In the latter country it was discovered by Dr Leach near Exeter, and he has twice obtained specimens that occurred near London.

Gen. 17. Eriodon. *Latreille, Leach.*

Missulena. *Walckanäer.*

*Lip* linear, esserted between the maxillæ. *Palpi* inserted at the external base of the maxillæ, which are dilated at that part. *Eyes* disposed somewhat like the letter H.

This genus was first established by Latreille, in the *Noveau Dictionnaire d'Histoire Naturelle*, xxiv. p. 133.

Sp. 1. *Occatorius.*

Missulène herseuse. *Walck. Tab. des Aran.* 8.

Eriodon occatorius.
*Latr. Gen. Crust. et Insect.* i. 86.
*Leach, Edin. Encycl.* vii. 421.

Inhabits Notasia. Discovered by Le Sueur and Peron.

*Stirps* 1. **

Gen. 18. Segestria.
*Latreille, Walckanäer, Leach.*

*Maxillæ* strait, longitudinal, with the base thickened, dilated externally, somewhat wedge-shaped, the middle longitudinally convex. *Lip* elongate-quadrate, longer than broad, the middle longitudinally convex or subcarinated. *Legs*, the first pair longest, rest in proportion, the second, then the fourth, the third pair being shortest. *Eyes* placed in a transverse line, the extremities somewhat recurved.

Sp. 1. *Senoculata.* Thorax blackish-brown; abdomen oblong, griseous, with a longitudinal band of blackish spots; legs pale brown with obscure bands.

Aranea senoculata. *Fabr. Ent. Syst.* ii. 426.

Segestria senoculata.
*Walck. Tab. des Aran.* 48.
*Latr. Gen. Crust. et Insect.* i. 89.
*Leach, Edin. Encycl.* vii. 421.

Inhabits rocks and old buildings. It is common in France, near Paris, and in England it is not rare.

*Segestria cellaria* has once been found at Plymouth in a cellar, and is now in Dr Leach's collection.

Gen. 19. Dysdera. *Latreille, Walckanäer, Leach.*

*Maxillæ* strait, longitudinal, with the base thickened and externally dilated at the insertion of the palpi; the apex internally obliquely truncated, and thence externally acutely terminated. *Palpi* with the first joint short and nearly obsolete. *Lip* elongate, quadrate, gradually narrowing towards its point. *Eyes* forming a horse-shoe, the open part in front. *Legs* with the first, then the fourth, then the second pair longest; the third shortest. *Claws* with a little brush beneath.

Sp. 1. *Eythrina.* Mandibles and thorax sanguineous; legs lightly coloured; abdomen soft, greyish yellow and silky.

Aranea Erythrina. *Fourcroy, Fn. Paris*, ii. 224.
Dysdera Erythrina.
*Latr. Gen. Crust. et Insect.* i. 90.
*Walck. Tab. des Aran.* 47.
*Leach, Edinb. Encycl.* vii. 421.
Plate XXIII.

Inhabits the south of France, and England, beneath stones. It is rare in the latter country, but has been taken in Devonshire, near Plymouth and Exeter, and near London. *Aranea Hombergii* of Scopoli, is merely a variety of this species.

*Stirps* 1. ***

Gen. 20. Filistata. *Latreille.*

*Eyes* placed on an uneven elevation, the four anterior ones forming a semicircle, open in front; the four hinder ones disposed in pairs, in nearly the same transverse line. *Maxillæ* much inclined towards the lip, with no groove at the insertion of the palpi. *Palpi* inserted in the lower side of the maxillæ. *Lip* much longer than broad. *Legs* with the fourth pair larger than the first pair.

This genus contains but one species. *Filistata testacea* of Walckanäer's MS. Of this animal, which was discovered near Marseilles, we have seen no description.

Gen. 21. Drassus. *Walckanäer, Latreille, Leach.*
Gnaphosa. *Latreille.*

*Palpi* inserted under the lateral and external margin of the maxillæ towards their middle. *Maxillæ* longitudinal, arcuated, gradually becoming broader from the base towards the middle, somewhat concave internally, smooth externally, their middle impressed, the points bent inwards above the lip, and obliquely truncated within. *Lip* elongate, ovate-quadrate, or rather oval; the base transversely truncated, inclosing the maxillæ. *Legs* with the first, and afterwards the second pair longest.

* *Lip somewhat oval; the external side of the maxillæ much bent and arched.*

Sp. 1. *Melanogaster.* Mandibles blackish; thorax and legs obscure brown; thighs light reddish-brown; abdomen cinereous-brown and silky.
Drassus melanogaster.
*Latr. Gen. Crust. et Insect.* i. 87.
Drassus lucifagus.
*Walck. Tab. des Aran.* 45.

Inhabits France and England, under stones.

** *Lip ovate-quadrate.*

Sp. 2. *Ater.* Entirely black.
Drassus ater.
*Latr. Gen. Crust. et Insect.* i. 87.
*Leach, Edin. Encycl.* vii. 422.

Inhabits the vicinity of Paris, and near London, beneath stones.

Gen. 22. Clotho. *Walckanäer, Latreille, Leach.*

*Maxillæ* much inclined towards the lip, with no groove at the insertion of the palpi. *Lip* not much longer than broad. *Feet* with the fourth, the second, then the third longest. *Eyes* close together, disposed four and four in two lines, bent backwards in somewhat a concentric manner; those of the hinder line disposed in pairs.

Sp. 1. *Durandii.* Thorax rusty brown, margined with pale yellow; abdomen black, with five red spots arranged 2, 2, 1; legs livid brown.
Clotho Durandii.
*Latr. Gen. Crust. et Ins.* vol. iv. append.
*Leach, Edin. Encycl.* vii. 422.

Inhabits Montpellier, building its web amongst stones.

Gen. 23. Clubiona. *Latreille, Walckanäer, Leach.*

*Maxillæ* strait and longitudinal; the basis a little dilated externally; the apex rounded and obliquely truncated on the inside. *Lip* elongate, quadrate, gradually narrowing towards the point. *Legs*, the first or the fourth pair longer than the second pair.

* *The two outermost eyes on either side neither placed very close together, nor inserted on a distinct prominence. (The maxilla in all with an incrassated base; the fourth pair of feet (rarely the first) longest.)*

Sp. 1. *Lapidicola.* Thorax and mandibles pale reddish; feet very light red; abdomen ash-grey coloured.
Clubiona lapidicola.
*Walck. Tab. des Aran.* 46.
*Latr. Gen. Crust. et Insect.* i. 91.
*Leach, Edin. Encycl.* vii. 422.

Inhabits France and England, under stones, constructing a globular cell of the size of a common hazel nut, in the centre of which are deposited a vast number of pale yellowish eggs, agglutinated into a spherical mass.

The mandibles of the male are porrect, and rather more than half of the length of the thorax; those of the female rather vertical.

** *The two external eyes on each side placed rather close to each other. (Maxillæ not always thickened at their base; the first and then the second pair of legs longest.)*

A. Maxillæ somewhat thickened at their base, and transversely impressed before the middle.

Sp. 2. *Nutrix.* Ungulæ black; thorax and mandibles light red; legs very light red; abdomen yellowish green, with an obscure longitudinal band.
Clubiona nutrix.
*Walck. Tab. des Aran.* 43.
*Latr. Gen. Crust. et Insect.* i. 92.
*Leach, Edin. Encycl.* vii. 422.

Inhabits the environs of Paris; it is common in a place called Sevres, building a nest amongst the leaves of the Eryngium campestre. Mandibles of the male stronger than those of the female.

It has once occurred in England, near Cheltenham.

B. Maxillæ not thickened at their base; front not transversely impressed.

Sp. 3. *Atrox.* Brown; legs pale; tibiæ with dark spots; middle of the back of the abdomen, with a somewhat quadrate black spot, margined with yellow.
Clubiona atrox.
*Walck. Tab. des Aran.* 44.
*Latr. Gen. Crust, et Insect.* 93.
*Leach, Edin. Encycl.* vii. 422.
Aranea atrox.
*De Geer, Mém. sur les Insect.* vii. 253. pl. 14. fig. 24, 25.

Inhabits old walls and fissures of rocks. It is very common in Britain and France. A tolerable figure

 is given in the work of Dr Lister on *British Spiders*, p. 68. fig. 21.

Gen. 24. ARANEA *of authors.*

TEGENERIA. *Walckanäer.*

*Maxillæ* strait and longitudinal, with their internal angle distinctly truncate, diameter equal, apex rounded. *Lip* elongate, nearly quadrate, longer than broad, towards the superior angles a little narrower. *Legs*, the anterior pair about the same length with the fourth pair; third pair shortest. *Eyes* disposed in two transverse lines near each other, and bent backwards.

Sp. 1. *Domestica.* Livid-cinereous; thorax of the *male* immaculate; of the *female* on each side with longitudinal blackish band; abdomen blackish, middle of its back with a longitudinal, maculose, dentated band, and the lateral lineolæ livid.

Aranea domestica.

*Fabr. Ent. Syst.* ii. 412.
*Linn. Syst. Nat.* i. 1031.
*Latr. Gen. Crust. et Insect.* i. 96.
*Leach, Edin. Encycl.* vii. 423.

Tegeneria domestica.

*Walck. Tab. des Aran.* 49.

Inhabits houses in Europe: spinning its web in a place where there is a cavity, such as the corner of a room. The mode of constructing the web is curious. Having chosen a convenient situation, she fixes one end of her thread to the wall, and passes on to the other side, dragging the thread along with her till she arrive at the other side, where she fixes the other end of it. Thus she passes and repasses until she has made as many parallel threads as are necessary; she then crosses these by other threads. This net is intended for the capture of her prey, and, in addition to it, the animal prepares a cell for herself, where she remains concealed, and on the watch. Between the cell and the net, the spider builds a bridge of threads, which, by communicating with the threads of the large net, both gives her intelligence when any thing touches the web, and enables her to pass quickly in order to seize it.

Gen. 25. AGELENA. *Walckanäer.*

*Maxillæ* strait and longitudinal, their internal angle slightly truncate; diameters equal, apex rounded. *Lip* not longer than broad, towards the superior angle a little narrower. *Legs* moderately long, the anterior and fourth pairs of nearly equal length, the third pair shortest. *Eyes* disposed in two transverse lines near to each other, and bent backwards.

Sp. 1. *Labyrinthica.* Griseous-pale-reddish; thorax on each side with a blackish longitudinal line; abdomen black, above and on each side with white oblique lines forming obtuse angles, running together anteriorly in pairs; the weaving appendices or nipples conic, elongate.

Aranea labyrinthica.

*Linn. Syst. Nat.* i. 1031.
*Fabr Ent. Syst.* ii. 418.
*Latr. Gen. Crust. et Insect.* i. 95.
*Leach, Edin. Encycl.* vii. 423.

Agelena labyrinthica.

*Walckanäer, Tab. des Aran.* 51.

Inhabits the fields. It is very common in most parts of Europe during the summer months. In Britain it is most abundant in the autumn. It spins a horizontal web on the ground, in which it watches for its prey, consisting principally of flies and other dipterous insects. The spider itself lives in a funnel-shaped cavity, often extending below the surface of the ground.



Gen. 26. ARGYRONETA. *Latreille, Walckanäer, Leach.*

*Maxillæ* short, strait, elongate-quadrate, the sides of nearly equal diameters; anteriorly convex; the apex rounded. *Lip* short, shorter than the maxillæ; of a narrow elongate-triangular form; the anterior aspect convex; the apex obtuse or truncate. *Legs*, the first, the fourth pair longest; the second pair shortest. *Eyes* with the four middle ones forming a quadrangle, the two on each side set obliquely and subgeminated.

Sp. *Aquatica.* Blackish-brown; abdomen black velvety, with some impressed dots on its back.

Aranea aquatica.

*Linn. Syst. Nat.* i. 1036.
*Fabr. Entom. Syst.* ii. 418.

Argyroneta aquatica.

*Latr. Gen. Crust. et Insect.* i. 95.
*Walck. Tab. des Aran.*
*Leach, Edin. Encycl.* vii. 423.

Inhabits Europe, frequenting slow running waters and ditches, in which it spins a web most beautifully constructed under the water, in which it lives, being surrounded by air, which shines through the water with a silvery lustre. The eggs are deposited in a globose silky bag. It is extremely common in most of the ditches round London, and may be observed, especially in the beginning of the summer, building its nest beneath the water, or running along the lines by which it is suspended.

*Stirps* 2. *

Gen. 27. SYCTODES. *Latreille, Walckanäer, Leach.*

*Maxillæ* oblique and longitudinal, covering the sides of the lip; their bases thickened, the apex internally obliquely truncated. *Lip* somewhat quadrate, the base a little contracted. *Legs* with the fourth, then the first pair longest; the third pair shortest.

Sp. 1. *Thoracica.* Pale reddish-white, spotted with black; thorax large and somewhat orbicular, elevated roundly behind; abdomen lighter in colour, and subglobose.

Syctodes thoracica.

*Walck. Tab. des Aran.* 79.
*Latr. Gen. Crust. et Ins.* i. 99. tab. 5. fig. 4.
*Leach, Edinb. Encycl.* vii. 423.

Inhabits Paris, in houses. It has twice occurred near Dover, but both the individuals were females.

Gen. 28. THERIDIUM.

THERIDION. *Walckanäer, Latreille, Leach.*

*Maxillæ* with an oblique direction covering the sides of the lip, converging towards their points; of equal breadth; the internal apex obtuse, or obliquely truncated. *Lip* small, triangular or semicircular; the apex truncate or subrounded. *Legs* elongate, the first, then the fourth pair longest. *Eyes* with four in the centre, forming a quadrangle, the under

ones placed on a common elevation; two others on each side geminated, and situated on a common elevation.

Sp. 1. *Sisiphum.* Rufous; abdomen globose, with white lines.

Theridion sisiphum.

*Latr. Gen. Crust. et Insect.* i. 97.

*Walck. Tab. des Aran.* 74.

*Leach, Edinb. Encycl.* vii. 423.

Inhabits Europe, in the corners of buildings, walls and rocks. It is figured by Lister, t. 14. f. 14.

Gen. 29. Latrodectus. *Walckanäer, Latreille.*

*Maxillæ*, with an oblique direction covering the sides of the lip, converging towards their points; of equal breadth; the internal apex truncate or subrounded. *Lip* small, triangular, or semicircular; the apex truncate or rounded. *Legs* elongate, the first then the second pair largest. *Eyes* placed four and four, in two transverse, strait and parallel lines.

Sp. 1. *Tredecim-guttatus.* Black, abdomen globose, with thirteen sanguineous spots.

Aranea, 13-guttata.

*Rossi, Fn. Etrus.* ii. 136. tab. 9. fig. 10.

*Fabr. Ent. Syst.* ii. 409.

Latrodecte Malmignatte. *Walck. Tab. des Aran.* 81.

Theridion tredecim-guttatum.

*Latr. Gen. Crust. et Insect.* i. 98.

*Leach, Edin. Encycl.* vii. 424.

Latrodectus, 13-guttatus.

*Latr. Considerat.* 424.

Inhabits Italy, and is not uncommon in the plains of that country.

Gen. 30. Pholcus. *Walckanäer, Latreille, Leach.*

*Maxillæ* oblique, covering the side of the lip, converging from the base to the apex; apex internally truncated. *Lip* transversely quadrate, the lateral angles of the apex rounded and somewhat margined. *Legs* very long and very slender; the first, then the second and fourth (nearly equal) longest. *Eyes* inserted on a tubercle, two geminated, and placed transversely in the middle; three on each side amassed in a triangle, one larger than the rest.

Sp. 1. *Phalangioides.* Pale-livid; abdomen elongate, cylindric oval, very soft, obscure cinereous; tip of the tibiæ and thighs with a pale ring of whitish colour.

Pholcus phalangiöides.

*Walck. Tab. des Aran.* 80.

*Latr. Gen. Crust. et Insect.* i. 99.

*Leach, Edin. Encycl.* vii. 424.

Aranea Pluchii.

*Scopol. Ent. Carn.* 1120.

Aranea opilionides.

*Schrank, Enum. Ins. Aust.* 1103.

Aranea phalangioides.

*Fouri. Ent. Paris*, ii. 213.

Inhabits houses in Europe; in the western parts of England it is extremely common. Its body vibrates like that of a tipulideous insect.

*Stirps* 2. **

Gen. 31. Uloborus. *Latreille, Leach.*

*Eyes* equal and very minute, disposed in two transverse lines, the first nearly strait, or scarcely bent backwards, the two middle eyes a little closer than the others; the posterior line bent forwards. *Maxillæ* strait, broad and inversely triagonal, the side broader than the apex. *Lip* very broad and semicircular. *Legs* with the first pair much the largest, then the fourth and afterwards the second, the third being consequently the smallest.

Sp. 1. *Walckanäcrius.* Pale reddish yellowed; thorax and abdomen silky, back white; abdomen oblong banded with fasciculi of hairs: legs banded with darker rings.

Uloberus Walckanäerius.

*Latr. Gen. Crust. et Insect.* i. 110.

*Leach, Edinb. Encycl.* vii. 424.

Inhabits the pines of Germany and France, in which it constructs its web.

Gen. 32. Tetragnatha. *Latreille, Leach.*

*Eyes* subequal, disposed in two strait and almost parallel transverse lines, the four middle ones forming nearly a regular quadrangle. *Maxillæ* strait, elongate and narrow, almost equally broad; the apex externally dilated and round: *Lip* semicircular and somewhat notched. *Legs* very long and very slender, the first pair longest, then the second, afterwards the fourth.

Sp. 1. *Extensa.* Reddish, abdomen oblong, golden green, with the sides and two lines below yellowish; the middle below longitudinally black.

Aranea extensa.

*Linn. Syst. Nat.* i. 1034.

*Fabr. Ent. Syst.* ii. 407.

Tetragnatha extensa.

*Latr. Gen. Crust. et Insect.* i. 101.

*Walck. Tabl. des Aran.* 68.

*Leach, Edinb. Encycl.* vii. 424.

Inhabits Europe, frequenting moist places, in which it constructs a vertical web, sitting on it with its legs extended.

Gen. 33. Linyphia. *Latreille, Walckanäer, Leach.*

*Eyes* with the four middle ones disposed in an irregular quadrangle; the eyes on each side geminated, and placed obliquely. *Maxillæ* nearly strait, inversely-suboval. *Lip* semicircular. *Legs* elongate and slender, the first pair longest, then the second, then the third.

Sp. 1. *Triangularis.* Pale reddish, inclining to yellow; thorax with a black dorsal line, bifid in front; abdomen oval, inclining to globose, with spots and angulated bands of brown and white; legs immaculate.

Linyphia triangularis.

*Latr. Gen. Crust. et Insect.* i. 100.

*Walck. Tabl. des Aran.* 70.

*Leach, Edinb. Encycl.* vii. 424.

Inhabits hedges in Europe, constructing its web on genistæ and pines.

Gen. 34. Epëira. *Walckanäer, Latreille, Leach.**

*Eyes* with the four middle ones placed on an abruptly formed tubercle, in the form of a quadrangle, the two anterior ones largest and most distant; the

* This genus, as defined by Latreille, requires much division into other genera: That author has divided the genus into sections, most of which would form good genera.

lateral eyes on each side subgeminated, and placed obliquely on a tubercle. *Maxillæ* subcircular, internally membranaceous. *Lip* semicircular, short with the point membranaceous. *Legs* moderately long, hispid, the thighs rather strong, the first pair largest, then the second, afterwards the fourth pair.

*Thorax* inversely elongate-subcordate, anteriorly broadly truncated. *Abdomen* subglobose, large, much broader than the thorax.

Sp. 1. *Diadema.* Reddish; abdomen globose-oval, with an elevated angle on each side of its base, dorsal band broad, triangular, dentated, darker, with a triple cross of luteous white dots or spots, and with four impressed dots disposed in a quadrangle.

Aranea Diadema.
*Linn. Syst. Nat.* i. 1030.
Araignée à croix.
*De Geer, Mém. sur les Insect.* vii. 218. pl. ii. f. 3.
Epëira Diadema.
*Walck. Tab. des Aran.* lviii.
*Latr. Gen. Crust. et Insect.* i. 106.
*Leach, Edinb. Encycl.* vii. 424.

Inhabits Europe. It frequents the borders of woods, rocks and gardens, and is well known in Britain by the names Sceptre or Diadem-spider.

Gen. 35. Nephila. *Leach.*

*Eyes* with the four middle ones placed on a gradually formed elevation, in the form of a quadrangle, the two anterior ones rather largest; the lateral ones on each side placed on a tubercle, subgeminated and set obliquely. *Maxillæ* elongate, with their base narrow, their apex truncate. *Lip* elongate, rather narrower at their base, the apex abruptly subacuminate. *Legs* elongate, slender, somewhat hairy, the first pair longest, then the second, then the fourth.

*Thorax* elongate-quadrate, anteriorly abruptly narrower, notched behind. *Abdomen* elongate, not or scarcely broader than the thorax.

Sp. 1. *Maculata.* Blackish; thorax fuscous-ferruginous; coxæ and base of the palpi croceous-luteous; abdomen luteous, the belly and sides infuscate; the latter with lines, the former with spots of white.

Aranea maculata. *Fabr.* 2. 134. t. 110.
Nephila. *Leach, Zool. Miscel.*

Inhabits China.

*Stirps* 3. ***

Gen. 36. Episenus. *Walckanäer, Latreille, Leach.*

*Eyes* forming the segment of a circle; of nearly an equal size, placed on an eminence. *Maxillæ* strait and longitudinal, the base a little dilated, the apex rounded. *Lip* very semicircular, much broader than long. *Legs* much lengthened; the anterior and then the fourth pair of legs longest; the third pair shortest.

Sp. 1. *Truncatus.* Thorax condiform, a little longer than broad, anteriorly acute; above obscure dark brown, beneath reddish brown; abdomen pyramidal, brown anteriorly, margined, behind truncated; third pair of legs whitish, the others brown, points of the first and fourth with white bases.

Episenus truncatus.
*Latr. Gen. Crust. et Insect.* i. 126.
*Leach, Edinb. Encycl.* vii. 425.

Inhabits the vicinity of Turin.

Gen. 37. Micrommata. *Latreille, Leach.*
Sparassus. *Walckanäer.*

*Eyes* subequal, disposed nearly in a semicircle, and surrounded by hairs. *Maxillæ* strait, quadrate-suboval, the longitudinal angle anteriorly; the internal side with a concave base, the apex obliquely truncated. *Lip* short and semicircular. *Legs* elongate; fourth longest, then the second, which are a little shorter than the first; the tips of the tarsi beneath furnished with a little double brush.

Sp. 1. *Smaragdina.* Bright green; back of the abdomen with dark longitudinal band; (that of the male with three longitudinal red lines.)

Micromate.
*Latr. Nouv. Dict. d'Hist. Nat.* 24. tab. p. 135.
Aranea smaragdula.
*Fabr. Ent. Syst.* ii. 412.
Sparassus smaragdulus.
*Walck. Tabl. des Aran.* 39.
Micrommata smaragdina.
*Latr. Gen. Crust. et Insect.* i. 115.
*Leach, Edin. Encycl.* vii. 426.

Gen. 38. Thomisus. *Walckanäer, Latreille, Leach.*
Heteropoda. *Latreille.*
Misumena. *Latreille.*

*Eyes* generally subequal, placed in two transverse lines in a kind of semicircle. *Maxillæ* oblique, covering the side of the lip, and in some degree converging; the internal apex truncate. *Lip* somewhat oval, or nearly quadrate, generally longer than broad. *Legs*, the first and second pair longest; the second pair rather longest; the third and fourth pair of legs much less, sometimes one being largest, sometimes the other.

The mandibles of the animals composing this genus, are either perpendicular or somewhat inflexed, in many conical, with very short claws.

* *Thorax convex, cordiform, the sides, especially behind, abruptly sloping, anteriorly broadly truncate; the largest legs not double the length of the body; the first and second pair much thicker than the others, sometimes one, sometimes the other being longest. The first joint of the tarsi, with several moveable little spines, in a single or in a double series, the claws of the tarsi naked. Lip sometimes oval, the apex truncate or obtuse. Apex of the maxilla wedge-shaped.*

Sp. 1. *Citrens.* Thorax at the insertion of the eyes transversely elevated; the sides anteriorly produced and prominent; eyes equal; abdomen roundish-triangonal, broader behind, with a red line on each side; body yellowish-citron-coloured.

Thomisus citreus.
*Walck. Tabl. des Aran.* 21.
*Latr. Gen. Crust. et Insect.* i. 111.
*Leach, Edinb. Encycl.* vii. 426.

Inhabits Europe, living in flowers. It is very common in Britain; the male is rare, smaller than the female, of a brown colour, banded with yellowish-green.

** *Thorax convex, cordiform, the sides, especially behind, abruptly sloping, the anterior part broadly truncated; the larger legs not twice the length of the body, all of nearly an equal*

*degree of thickness; the hinder four not much shorter; the anterior with four little spines; the claws of all the tarsi scarcely visible. Lips somewhat oval; the apex truncate or obtuse. Maxillæ at their points wedge-shaped.*

Sp. 2. *Lynceus.* Lateral eyes largest, placed on an eminence, the tubercles of the hinder ones thickest; body pale yellowish-grey, variegated with punctures and spots of a blackish colour; abdomen very large, of a triangular-oval form, broader behind.

Thomisus lynceus.
*Latr. Gen. Crust. et Insect.* i. 112.
*Leach, Edinb. Encycl.* vii. 426.

Inhabits France and Scotland. Latreille considers it to be much allied to *Thomisus onustus* of Walckanäer.

*** *Thorax depressed, somewhat oval, very obtuse before; the larger legs not twice the length of the body: all the legs of equal thickness; the tarsi hairy beneath, the first joint with a few little spines; the apex with two brushes under the claws; abdomen oblong; the maxillæ beyond the insertion of the palpi, nearly of an equal breadth, distinctly and abruptly truncated; lip somewhat quadrate; hinder eyes distant.*

Sp. 3. *Oblongus.* Pale-yellowish, with white hairs above; abdomen somewhat cylindrical, with obscure longitudinal lines.

Thomisus oblongus.
*Walck. Tabl. des Aran.* 38.
*Latr. Gen. Crust. et Insect.* i. 113.
*Leach, Edinb. Encycl.* vii. 426.

Inhabits France, Denmark, and England, on plants.

**** *Thorax depressed, cordiform, anteriorly truncated; the four anterior legs more than double the length of the body; the under parts of the tarsi generally hairy, always furnished with two little brushes under the claws; maxillæ short, much inflexed above the lip, nearly of an equal breadth beyond the insertion of the palpi; apex abruptly truncated; lip nearly quadrate, broad; the second pair of legs longest.*

A. *Tarsi hairy beneath. Eyes disposed in two nearly parallel lines; the third pair of legs shorter than the fourth.*

Sp. 4. *Regia.* The four lateral eyes largest; body pale-dirty yellow, inclining to red; thorax, with the anterior margin, and a posterior band yellowish-grey, the hinder band margined with black above.

Aranea regia. *Fabr. Ent. Syst.* ii. 408.
Thomisus leucosia.
*Walck. Tabl. des Aran.* 36.
*Latr. Gen. Crust. et Insect.* i. 113.
*Leach, Edinb. Encycl.* vii. 426.

Inhabits the Isle of France.

B. *Tarsi scarcely hairy beneath. Eyes disposed in a semicircle; third pair of legs longer than the fourth.*

Sp. 5. *Venatorius.* Yellowish-red; abdomen yellow-grey, clouded with ash-grey; legs spotted with black.

Aranea venatoria. *Linn. Syst. Nat.* i. 1035.



Thomisus venatorius.
*Latr. Gen. Crust. et Insect.* i. 114.
*Leach. Edinb. Encycl.* vii. 427.

Inhabits the American Islands.

*Obs.* Aranea venatoria of Fabricius, is the same with the Mygale nidulans of Walckanäer.

C. *Tarsi scarcely hairy beneath. Eyes placed in a semicircle. Third pair of legs longer than the fourth.*

Sp. 6. *Levipes.* Body grey, spotted with black; abdomen plain, rhomboidal.

Aranea levipes.
*Linn. Syst. Nat.* i. 1037.
*Fab. Ent. Syst.* ii. 413.
Thomisus tigrinus.
*Latr. Gen. Crust. et Insect.* i. 114.
*Walck. Tabl. des Aran.* 34.
Thomisus levipes.
*Leach, Edinb. Encycl.* vii. 427.

Inhabits Europe; it resides on the branches of trees, and runs with great celerity.

*Stirps 3.* *

Gen. 39. OXYOPES. *Latreille, Leach.*
SPHASUS. *Walckanäer.*

*Maxillæ* strait, longitudinal and elongate, of an equal breadth from the base to the apex, which is externally gradually arcuated, internally obliquely truncated. *Lip* oblong-quadrate. *Legs* long and slender; the first pair longest, then the fourth and second, which are nearly of equal length; *tarsi* short; *claws* exserted, with no brush beneath. *Eyes* disposed in four transverse lines, forming an elongate hexagon.

Sp. 1. *Variegatus.* Body hairy and grey, variegated with red and white; legs pale, reddish, spotted with brown; the tibial spines elongate.

Oxyope.
*Latr. Nouv. Dict. d'Hist. Nat.* tom. xxiv. tabl. p. 135.
Spasus heterophthalmus.
*Walck. Tab. des Aran.* xix.
Oxyopes variegatus.
*Latr. Gen. Crust. et Insect.* i. 116.
*Leach, Edin. Encycl.* vii. 427.

Inhabits France.

Gen. 40. STORENA. *Walckanäer, Latreille, Leach.*

*Maxillæ* much longer than the lip, which they cover. *Lip* oval and lengthened. *Eyes* disposed in three transverse lines, forming a nearly equal sided hexagon.

Sp. 1. *Cœrulea.*

Storène bleue. *Walckanäer.*
*Latreille, Considerat.* 424.

Gen. 41. CTENUS. *Walckanäer, Latreille, Leach.*

*Maxillæ* strait. *Lip* very much shorter than the maxillæ. *Eyes* disposed in three transverse lines, forming an angulated curved line.

Sp. 1. *Ambiguus.*

Ctène douteux.
*Walckanäer.*
*Latreille, Consider.* 424.

*Stirps 3.* **

Gen. 42. LYCOSA. *Latreille, Walckanäer, Leach.*

*Maxillæ* strait, anteriorly convex; externally

towards the side, somewhat arcuated, internally slightly margined, gradually narrowing towards the base; the apex obliquely truncated, forming almost an inverted triangle. *Lip* elongate, quadrate. *Legs* strong, the fourth pair longest, then the second; the third shortest.

Sp. 1. *Tarentula.* Body above cinereous-fuscous; mandibles and palpi towards their middles ferrugineous, their tips black; thorax with a radiated dorsal line and margins griseous; abdomen anteriorly above with trigonal spots, behind with arcuate, transverse streaks of black, bordered with white; beneath bright saffron colour, with a transverse black band; thighs and tibiæ beneath rufous-white, with two black spots.

Aranea tarentula.
*Linn. Syst. Nat.* i. 1035.
*Fabr. Ent. Syst.* ii. 425.

Lycosa tarentula.
*Walck. Tabl. des Aran.* xi.
*Latr. Gen. Crust. et Insect.* i. 119.
*Leach, Edinb. Encycl.* vii. 427.

Inhabits the south of Europe. This species is the celebrated Tarentula spider, of which such marvellous accounts have been given by travellers, who have described its bite as generally fatal, and to be curable only by music, the effects of which were, to cause the patient to dance until a profuse perspiration was produced, by which a certain cure was effected.

The name tarentula is derived from Tarentum (now Taranto), in the kingdom of Naples, near which place they were supposed to be found in the greatest plenty. It is figured in Albin's spiders, tab. 39.

Sp. 2. *Saccata.* Above smoky-black, clouded with cinereous villosity; carina of the thorax obscure, reddish, with a cinereous villous line; base of the abdomen with a little bundle of griseous hairs; legs livid-red, with blackish spots.

Lycosa saccata.
*Walck. Tabl. des Aran.* 13.
*Latr. Gen. Crust. et Insect.* i. 120.
*Leach, Edinb. Encycl.* vii. 427.

Inhabits Europe. It is very common in Britain; the female may be observed in gardens, carrying her bag of eggs, of a green colour. Palpi, mandibles and anterior margin of the thorax livid red in the female, black in the male.

Gen. 43. Dolomedes.
*Latreille, Walckanäer, Leach.*

*Maxillæ* strait, oval-quadrate, the apex externally rounded, internally obliquely truncated. *Lip* somewhat square, the diameters nearly equal, the points of the angles rounded. *Legs* elongate, the fourth pair longest, then the second, the third shortest: *Claws* exserted without brushes below.

Sp. 1. *Mirabilis.* Pale reddish, covered with greyish down; thorax heart-shaped, anteriorly, abruptly sloping; the anterior angles and dorsal line whitish; abdomen conical, suboval, back darker.

Aranea saccata.
*Linn. Syst. Nat.* i. 1036.

Dolomedes mirabilis.
*Walck. Tabl. des Aran.* 16.
*Latr. Gen. Crust. et Insect.* i. 117.
*Leach, Edin. Encycl.* vii, 427.



Aranea Listeri.
*Scopol. Ent. Carn.* 1093?

Aranea obscura.
*Fabr. Ent. Syst.* ii. 419.

Inhabits the woods of Europe. The female carries about her eggs inclosed in a dirty orange-coloured or whitish bag; this economy is common to the whole genus.

*Stirps* 4.

Gen. 44. Eresus. *Walckanäer, Latreille, Leach.*

*Maxillæ* strait, longitudinal, subcuneiform, the apex broader, externally rounded, internally obliquely truncated. *Legs* strong, short, formed for leaping; the fourth pair longest, then the first; the third pair shortest, a little shorter than the second. *Eyes* disposed in two quadrangles, one quandrangle inclosed by another.

Sp. 1. *Moniligerus.* Black; abdomen above cinnabar-coloured, with four or six black dots, arranged in two longitudinal lines; joints of the legs whitish; hinder sides of the thorax, the thighs, and the first joint of the four hinder legs pale-cinnabar.

Eresus cinnabarinus.
*Walck. Tabl. des Aran.* 21.
*Latr. Gen. Crust. et Insect.* i. 122.
*Leach, Edin. Encycl.* vii. 428.

Aranea moniligera.
*Villers, Ent.* iv. 128. tab. 11. f. 8.

Aranea quadriguttata.
*Rossi, Fn. Etrusc.* ii. 135. pl. 1. f. 8, 9.

Inhabits France, Germany, and England.

Gen. 45. Salticus. *Latreille, Leach.*
Attus. *Walckanäer.*

*Maxillæ* strait, longitudinal, subrhomboidal, or inverse-cuneate-ovate. *Lip* elongate suboval, the apex obtuse. *Palpi* clavate. *Thorax* truncate-ovate or parallelogrammic. *Eyes* disposed in the form of a horse-shoe, the two middle ones largest. *Legs* thick and short; the first pair thickest and not longer than the fourth pair; the second and the third pairs of nearly an equal length, and shorter than the two other pairs.

Sp. 1. *Scenicus.* Black; margin of the thorax covered with white down; abdomen short ovate, above with a reddish-gray pubescence, with three transverse arcuate lines, and the anus white; the first band basal and entire, the others acutely bent anteriorly, and interrupted in their middle.

Aranea scenica.
*Linn. Syst. Nat.* i. 1035.
*Fabr. Ent. Syst.* ii. 422.

Atte paré. *Walck. Tabl. des Aran.* 24.

Salticus scenicus.
*Latr. Gen. Crust. et Insect.* i. 123.
*Leach, Edin. Encycl.* vii. 428.

Inhabits walls and palings. It is found in most parts of Europe, and is called in Britain the Hunting-spider.

Palpi of the female whitish; legs of the same sex reddish-gray, with darker spots. Male with very large mandibles.

Gen. 46. Attus. *Walckanäer.*
Salticus. *Latreille, Leach.*

*Maxillæ* strait, longitudinal, subrhomboidal or

inversely cuneate-ovate. *Lip* elongate, suboval, with the apex obtuse. *Palpi* filiform. *Thorax* elongate, narrow, subconic. *Eyes* disposed in the form of a horse-shoe; the two middle eyes largest. *Legs* slender, elongate, the first pair thickest and not longer than the fourth pair; the second and third pairs of nearly an equal length, and shorter than the two other pairs.

This genus we have separated from Salticus, with which it was placed by Latreille; and we have given it the name applied by Walckanäer to both these genera, which he did not think distinct from one another.

Sp. 1. *Formicarius.* Thorax anteriorly black, behind red; abdomen fuscous, with a white spot on each side; legs red.

Attus formicarius.
*Walck. Tabl. des Aran.* 26.
Salticus formicarius.
*Latr. Gen. Crust. et Insect.* i. 124.
*Leach, Edin. Encycl.* vii. 428.
Araignée fourmi.
*De Geer, Mém. sur les Insect.* vii. 293. tab. 18. fig. 1, 2.

Inhabits Europe, residing on plants and walls. It is very rare in Scotland, and has not been observed in England.

Order IV. MONOMEROSOMATA.

SECTION I.

*Legs formed for walking.*

A. *Mouth with mandibles.*

Fam. I. TROMBIDIDEÆ. *Palpi* porrect, and furnished at their extremities with a moveable appendage.

*Stirps* 1. *Eyes* two placed on a pillar. *Body* apparently divided into two parts by a transverse line; the anterior division bearing the eyes, mouth and four anterior legs.

Genus 47. TROMBIDIUM.
48. OCYPETE.

*Stirps* 2. *Body* not divided by a transverse line. *Palpi* with the under part of their last joint furnished with a moveable appendage. *Eyes* sessile.

Genus 49. ERYTHRÆUS.

Fam. II. GAMMASIDEÆ. *Palpi* porrect, simple.

Genus 50. GAMMASUS.

Fam. III. ACARIDEÆ. *Mouth* furnished with mandibles. *Palpi* simple, very short, not porrected.

Genus 51. ORIBITA.
52. NOTASPIS.
53. ACARUS.

B. *Mouth furnished with a rostrum.*

Fam. IV. IXODIDEÆ. *Eyes* obscure or concealed.

*Stirps* 1. *Palpi* and *Rostrum* exserted.

Genus 54. ARGAS.
55. IXODES.

*Stirps* 2. *Palpi* and *Rostrum* hidden.

Genus 56. UROPODA.

Fam. V. CHEYLETIDEÆ. *Eyes* distinct.

*Stirps* 1. *Palpi* distinct.

Genus 57. CHEYLETUS.
58. SMARIS.
59. BDELLA.

*Stirps* 2. *Palpi* concealed.

Genus 60. SARCOPTES.

SECTION II.

*Legs formed for swimming.*

Fam. I. EYLÄIDEÆ. *Mouth* furnished with mandibles.

Genus 61. EYLÄIS.

Fam. II. HYDRACHNIDEÆ. *Mouth* without mandibles.

Genus 62. HYDRACHNA.
Genus 63. LINNOCHARES.

Section I. A.

Family I. TROMBIDIDEÆ. *Stirps* 1.

Gen. 47. TROMBIDIUM *of authors. Legs* eight.

Sp. 1. *Tinctorium.* Body subquadrate, coccineous, immaculate, very tomentose and hairy; the hairs setaceous, elongate, bearded.

Acarus tinctorius. *Linn. Syst. Nat.* i. 1025.
Trombidium tinctorium.
*Fabr. Ent. Syst.* ii. 398.
*Latr. Gen. Crust. et Insect.* i. 145.
*Leach, Edin. Encycl.* vii. 416.

Inhabits Guinea: It is often preserved in collections, and is probably a common animal. Its colour is destroyed by alcohol.

Gen. 48. OCYPETE. *Leach.*

*Legs* six.

Sp. 1. *Rubra.* Red; back with a few long hairs, the legs with many short hairs of a rufous-cinerescent colour; eyes black-brown.

Ocypete rubra. *Leach, Trans. Linn. Soc.* xi.
——— *Edinb. Encycl.* vii. 434.

This curious little animal, which is not larger than a grain of small sand, is parasitic, and is frequently to be found on the largest tipularidous insects, adhering to their legs. We have obtained no less than sixteen specimens from one insect.

Family I. *Stirps* 2.

Gen. 49. ERYTHRÆUS. *Latreille, Leach.*

*Palpi* with their moveable appendage subcheliferous. *Hinder legs* longest, then the first.

Sp. 1. *Phalangioides.* Legs very long, the last joint broad, compressed; body obscure-red, with a dorsal band of orange-yellow.

Erythræus phalangioides.
*Latr. Gen. Crust. et Insect.* i. 146.
*Leach, Edin. Encycl.* vii. 416.

Inhabits Europe, running on the ground with great rapidity.

Family II. GAMMASIDEÆ.

Gen. 50. GAMMASUS. *Latreille, Leach.*

*Body* depressed, the skin of the back partly or entirely coriaceous.

* *Anterior portion of the back, and a triangular part behind, coriaceous.*

Sp. 1. *Coleoptratorum.* Coriaceous parts of the back fuscous; anterior pair of legs a little longer than the hinder ones.

Gammase des Coléoptères.
*Latr. Hist. Nat. des Crust. et des Insect.* vii. 399.
Gammasus coleoptratorum.
*Latr. Gen. Crust. et Ins.* i. 147.
*Leach, Edin. Encycl.* vii. 415.

Arachnides. Acarus coleoptratorum.

*Linn. Syst. Nat.* i. 1026.

*Fabr. Ent. Syst.* iv. 432.

Inhabits the excrements of horses and oxen, often attaching itself to Scarabæi, Histeres, &c. in great numbers; we have counted nearly one hundred on Scarabæus stercorarius (the common Dorbeetle).

** *Back entirely coriaceous.*

Sp. 2. *Marginatus.* Ovate, brown; belly coriaceous, the sides alone membranaceous and whitish; anterior legs nearly twice the length of the body.

Gammasus marginatus.

*Latr. Gen. Crust. et Insect.* i. 148.

*Leach, Edin. Encycl.* vii. 415.

Inhabits dung and dead animals.

Family III. Acarideæ.

Gen. 51. Oribita. *Latreille, Leach.*

*Body* covered by a coriaceous skin; anterior part rostrated; the produced part inclosing the organs of mastication. *Abdomen* subglobose. *Tarsi* with claws.

Sp. 1. *Geniculata.* Fuscous-castaneous, shining, hairy; legs pale-fuscous; thighs subclavate.

Acarus geniculatus. *Linn. Syst. Nat.* i. 1025.

Oribita geniculata.

*Latr. Gen. Crust. et Insect.* i. 149.

*Leach, Edin. Encycl.* vii. 415.

Inhabits trees and beneath stones. It is common in Sweden, Germany, and England.

Gen. 52. Notaspis. *Hermann.*

*Body* covered by a coriaceous skin, the anterior part rostrated, the produced part inclosing the organs of mastication. *Abdomen* subglobose, the sides anteriorly with a wing-like process. *Tarsi* with claws.

Sp. 1. *Humeralis.* Abdomen blackish-chesnut; the produced parts membranaceous.

Mitte à rebord.

*De Geer, Mém. sur les Insect.* vii. 133? pl. 8. fig. 6.

Oribita humeralis.

*Latr. Gen. Crust. et Ins.* i. 150.

*Leach, Edin. Encycl.* vii. 415.

Inhabits moss, and beneath stones. It is not uncommon in the southern parts of Devonshire.

Gen. 53. Acarus *of authors.*

*Body* soft. *Mouth* naked. *Tarsi* with a pedunculated vesicle at their extremities.

Sp. 1. *Domesticus.* White, with two brown spots; body ovate, the middle coarctate, with very long hairs; legs equal.

Ciron du fromage. *Geoff. Hist. des Insect.* ii. 622.

Mitte domestique.

*De Geer, Mém. sur les Insect.* vii. 88. pl. 5. fig. 1—4.

Acarus siro.

*Linn. Syst. Nat.* i. 1024.

*Fabr. Ent. Syst.* iv. 430.

*Leach, Edin. Encycl.* vii. 415.

Acarus domesticus.

*Latr. Gen. Crust. et Insect.* i. 150.

Tyroglyphus.

*Latr. Préc. des Caract. Génér. des Insect.* 185.

Inhabits houses, living in cheese and flower that have been kept too long.

Section I. B.

Family IV. Ixodideæ. *Stirps* 1.

Gen. 54. Argas. *Latreille, Leach.*

Rhynchoprion. *Hermann.*

*Palpi* short, conic, four-jointed.

Sp. 1. *Marginatus.* Pale-yellowish, or fleshy violet, margined; with very short squamulæ, with branched blood-vessels.

Acarus marginatus. *Fabr. Ent. Syst.* iv. 427.

Argas reflexus.

*Latr. Gen. Crust. et Insect.* i. 155.

*Leach, Edin. Encycl.* vii. 414.

Plate XXIII.

Inhabits houses in France, sucking the blood of doves.

Gen. 55. Ixodes. *Latreille, Leach.*

Cynorhæstes. *Hermann.*

*Palpi* equally broad, longer than broad.

Dr Leach has written a paper on the British species of this genus, in the eleventh volume of the *Transactions of the Linnean Society.*

Sp. 1. *Ricinus.* Scutus rounded, smaller; with the vagina of the rostrum, and the legs fuscous; abdomen varying in colour.

Acarus ricinus.

*Linn. Syst. Nat.* i. 1023.

*Fabr. Ent. Syst.* iv. 425.

Idodes ricinus.

*Latr. Gen. Crust. et Insect.*

*Leach, Edin. Encycl.* vii. 414.

—— *Trans. Linn. Soc.* xi.

Inhabits Europe, attaching itself to dogs. In Britain it is called the Dog ticque.

Family IV. *Stirps* 2.

Gen. 56. Uropoda. *Latreille, Leach.*

*Body* oval, orbiculate; back corneous, clypeiform, the disc being gradually convex; beneath flat. *Anus* produced into a long filiform peduncle (by which it adheres to coleopterous insects). *Legs* very short, pressed close to the body, the first pair shortest, the second rather longer, the third distinctly longer, the fourth pair longest.

Sp. 1. *Vegetans.* Brown, very smooth, shining.

Mitte vegetative.

*De Geer, Mém. sur les Insect.* vii. 123. pl. 7. fig. 15.

*Latr. Hist. Nat. des Crust. et Insect.* vii. 381, *et* viii. pl. 67. f. 8.

Uropoda vegetans.

*Latr. Gen. Crust. et Insect.* i. 158.

*Leach, Edin. Encycl.* vii. 414.

Inhabits France and England, attaching itself to the legs, abdomen, and elytra of histeres, aphodii, &c. by its pedunculated anus.

Family V. Cheyletideæ. *Stirps* 1.

Gen. 57. Cheyletus. *Latreille, Leach.*

*Palpi* brachiiform, very thick, their points falcate.

Sp. 1. *Eruditus.* Body brownish.

Acarus eruditus.

*Schr. Enum. Insect. Aust.* 1058. tab. 2. fig. 1.

Cheyletus eruditus.

*Latr. Gen. Crust. et Ins.* i. 153.

*Leach, Edin. Encycl.* vii. 414.

Inhabits books and Musæa.

Gen. 58. Smaris. *Latreille, Leach.*

*Palpi* small, filiform, strait, simple. *Eyes* two. *Anterior legs* longest.

Sp. 1. *Sambuci.*

Acarus sambuci. *Schr. Enum. Ins. Austr.* 1085.

Smaris sambuci.

*Latr. Gen. Crust. et Insect.* i. 153.

*Leach, Edinb. Encycl.* vii. 414.

Inhabits the trunks of trees, especially those of the Elder.

Gen. 59. Bdella. *Latreille, Lamarck.*

Scirus. *Hermann.*

*Palpi* small, filiform, long, geniculated, the apex setigerous. *Eyes* four. *Hinder legs* longest.

Sp. 1. *Rubra.* Body coccineous, legs paler, rostrum longer than the thorax.

Bdelle rouge.

*Latr. Hist. Nat. des Crust. et des Insect.* viii. 53. pl. 67. fig. 7.

Bdella rubra.

*Lam. Syst. des Anim. sans Vertéb.* 179.

*Latr. Gen. Crust. et Insect.* i. 154.

*Leach, Edin. Encycl.* vii. 414.

Inhabits Europe, under stones. It is the *Pince rouge* of Geoffroy, and is probably the *Acarus longicornis* of Linné.

Family V. *Stirps* 2.

Gen. 60. Sarcoptes. *Latreille, Leach.*

Sp. 1. *Scabiei.* Subrotundate; legs short, reddish; four hinder ones, with a very long seta, the plantæ of the four anterior ones terminated by a swelling.

Mitte de la Gale.

*De Geer, Mém. sur les Insect.* ii. 622.

Le Ciron de la Gale.

*Geoff. Hist. des Insect.* ii. 622.

Acarus Scabiei. *Fabr. Ent. Syst.* iv. 430.

Sarcopte de la Gale.

*Latr. Hist. Nat. des Crust. et des Insect.* viii. 55. *et* vii. pl. 66.

Sarcoptes scabiei.

*Latr. Gen. Crust. et Insect.* i. 152.

*Leach, Edin. Encycl.* vii. 413.

Inhabits the ulcers of the itch. *Acarus exulcerans* of Linné is probably this animal, or is at least referable to the same genus.

### Section II.

Family I. Elyaideæ.

Gen. 61. Elyäis. *Latreille, Lamarck, Leach.*

*Mandibles* depressed, armed at their joints with a claw. *Palpi* elongate-conic, arcuate. *Eyes* four.

Sp. 1. *Extendens.* Body rounded, shining, smooth, red, immaculate; hinder legs strait.

Eläis extendens.

*Lam. Syst. des Anim. sans Vertéb.* 177.

*Latr. Gen. Crust. et des Insect.* i. 158.

*Leach, Edinb. Encycl.* vii. 413.

Hydrachna extendens.

*Müll. Hydr.* 62. tab. 9. f. 4.

Trombidium extendens.

*Fabr. Ent. Syst.* ii. 406.

Inhabits stagnant waters.

Family II. Hydrachnideæ.

Gen. 62. Hydrachna. *Müll. Oliv. Latr. Leach.*

*Palpi* subcylindric, porrect, arcuate-inflexed, four-jointed, the last acute, unguiform. *Mouth* produced into a conic rostrum. *Body* globose. *Legs* fimbriated with hairs, and situated at equal distances from one another.

Sp. 1. *Geographica.* Black, with coccineous spots and dots.

Hydrachna geographica.

*Müll. Hydr.* 59. tab. 8. fig. 3—5.

*Latr. Gen. Crust. et Insect.* i. 159.

*Leach, Edinb. Encycl.* vii. 413.

Inhabits waters that flow gently. It is a most beautiful animal, and is very common in some parts of Britain.

Gen. 63. Limnochares. *Latreille, Leach.*

*Palpi* incurved, the apex acute simple. *Mouth* with a very short rostrum. *Body* depressed. *Legs* short, the four hinder ones remote. *Eyes* two.

Sp. 1. *Holosericea.* Body ovate, red, rugose, soft; eyes black.

Acarus aquaticus.

*Linn. Syst. Nat.* i. 1025.

La tique rouge satinée aquatique.

*Geoff. Hist. des Insect.* ii. 625.

Mitte satinée aquatique.

*De Geer, Mém. sur les Insect.* i. 149. pl. 9. 15—17.

Trombidium aquaticum.

*Fabr. Ent. Syst.* ii. 399.

Limnochares holosericea.

*Latr. Gen. Crust. et Insect.* i. 160.

*Leach, Edinb. Encycl.* vii. 413.

Inhabits the waters of Europe. It is very common in most of our ponds during the summer months. It varies much in colour, but is generally found of a bright red or greyish-red colour, and of all the intermediate varieties of shade.

Fabricius says that it deposits its eggs on Nepæ (water-scorpions), and that they are of a red colour.

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*Arachnideous Genera of uncertain situation.*

Gen. 64. Trogulus. *Latreille.*

*Body* ovate-elliptic, depressed. *Eyes* two, placed on the back, but not on a common tubercle. *Legs* eight, elongate, filiform, the second pair longest, then the fourth, which is scarcely shorter; the third and fourth afterwards: *tarsi* with a horny claw. *Mandibles* cylindric, compressed, elongate, biarticulate, geniculated, the last joint didactyle, the fingers equal, towards their points unidentate. *Palpi* filiform, a little longer than the mandibles, geniculated, five-jointed, the last furnished at its point with a very minute corneous claw.

For a more detailed character of this genus, see Latreille's *Genera Crustaceorum et Insectorum*, Vol. I. p. 141. where it is placed next to Phalangium. In his last work, Latreille has grouped it with Siro, and has put it in the second division of his family Phalangita.

Sp. 1. *Nepæformis.* Obscure-cinereous or earth-coloured; middle of the back of the abdomen and the sides obsoletely subcarinated; external apex of the first joint of the tarsi produced.

Phalangium tricarinatum.

*Linn. Syst. Nat.* i. 1029.

Acarus nepæformis.

*Scopol. Ent. Carniol.* 1070.

 Phalargium carinatum.

*Fabr. Ent. Syst.* ii. 431.

Trogulus nepæformis.

*Latr. Gen. Crust. et Insect.* i. 142. tab. 6. f. 1.

*Leach, Edinb. Encycl.* vii. 416.

Inhabits France and Germany, lurking under stones.

Gen. 65. CELLULARIA. *Montagu.*

The singular animal, that forms the type of the genus *Cellularia*, was discovered by Montagu, and described by him in the first volume of the *Memoirs of the Wernerian Natural History of Edinburgh*, page 191, and, as we have never seen it, we must extract the description given by that ingenious zoologist.

" Ovate-oblong, smooth, glossy white, with eight short legs, furnished with several joints and terminated by bristles, two on each side approximating and near to the anterior end, the others similarly disposed, about one third of its length from the posterior end; of the posterior legs, the hindermost pair is furnished with a very long bristle, the other pair usually with two; the anterior legs possess several bristles each. No other appendages were discernible under the best constructed microscope, not even the mouth or eyes could be clearly ascertained; but beneath, at the anterior end, and from whence the fore legs arise, there are four light depressions, surrounded by dark lines, in the two hindermost of which is a dark spot, but had not the appearance of the eyes; behind this part is usually a fold in the skin, in which there is an independent motion; the feet were also observed to be in continual alternate motion, whilst under the microscope.

" Size of the cheese mite.

" As far as I have hitherto observed, this animal is peculiar to the gannet, and does not appear to inhabit any other part than the cellular membrane. In some subjects it is found in considerable numbers, together with its ova; and no instance has occurred in which it has not appeared more or less in every specimen dissected.

" To class this animal with any of the Linnean genera, is impossible; nor am I acquainted with any genus in the arrangement of any more modern systematic writers, in which it could with propriety be placed. Under these circumstances, I propose giving it a distinct place in the system of nature, under the title of CELLULARIA *Bassani*, with the following generic characters: head thorax and abdomen united; no eyes, antennæ, palpi nor proboscis; legs eight, the four posterior remote from the four anterior; feet unarmed, but furnished with bristles."

Gen. 66. CARIS. *Latreille, Leach.*

" *Legs* six. *Palpi* subconic, porrect, four-jointed, of the length of the rostrum. *Rostrum* conic, porrect. *Body* coriaceous, depressed, suborbiculate." *Latreille.*

Sp. 1. *Vespertilionis.* Body fuscous.

La tique de la chauve-souris?

*Geoff. Hist. des Insect.* ii. 627.

Caris vespertilionis.

*Latr. Gen. Crust. et Insect.* i. 161.

*Leach, Edinb. Encycl.* vii. 413.

Inhabits bats (vespertilionidea).

Gen. 67. LEPTUS. *Latreille.*

" *Legs* six. *Palpi* short, subconic. *Mouth* with a porrected rostrum. *Body* soft, generally oval." *Latreille.*

Can this be synonymous with our genus *Ocypete?*

Sp. 1. *Phalangii.* Body oval, coccineous, anteriorly subcapitate, with two black eyes and a subconic rostrum; first joint of the palpi very much incrassated; legs subequal.

Pediculus coccineus. *Scopol. Ent. Carn.* 1055.

Mitte des Faucheurs.

*De Geer, Mém. sur les Insect.* vii. 117. pl. 7. f. 5.

Acarus Phalangii. *Fabr. Ent. Syst.* iv. 433.

Leptus Phalangii.

*Latr. Gen. Crust. et Insect.* i. 162.

*Leach, Edin. Encycl.* vii. 413.

Inhabits Phalangium opilio.

Gen. 68. ASTOMA. *Latreille.*

" *Legs* six. *Mouth* beneath, nearly obsolete; parts of the mouth not visible. *Body* soft, oval. *Legs* very short." *Latreille.*

Sp. 1. *Parasiticum.* Body coccineous, the middle slightly contracted.

Mitte parasite.

*De Geer, Mém. sur les Insect.* vii. 118. pl. 7. fig. 7.

Astoma parasiticum.

*Latr. Gen. Crust. et Insect.* i. 162.

Inhabits flies and other insects.

Latreille placed the three last mentioned genera in a family which he named *Micropthira;* and, in the *Edinburgh Encyclopædia*, Dr Leach put them in a particular tribe, named *Hexapoda*, under which he arranged all the Arachnides that have six legs.

## Subclass II. NOTOSTOMATA.

This subclass contains the genera *Nycteribia* of Fabricius and Latreille, *Phthiridium* of Hermann.

We shall simply give references to one species, and a definition of the genus containing it.

Genus 69. PHTHIRIDIUM. *Hermann.*

NYCTERIBIA. *Latreille.*

*Abdomen* of one sex two-jointed, terminated by two cylindric processes, bearing setæ; of the other sex six-jointed.

Sp. 1. *Hermanni.*

Plate XXIII. represents the sexes of this species, with a leg highly magnified.

Phthiridium biarticulatum.

*Hermann, Mém. Apterol.* 124. pl. 6. fig. 1.

Celeripes vespertilionis.

*Montagu, Trans. Linn. Soc.* ix. 166, note.

Nycteribia vespertilionis.

*Montagu, Trans. Linn. Soc.* xi. 11. tab. 3. fig. 5.

Inhabits the lesser and greater horse-shoe bats of England.

OBS. *Nycteribia vespertilionis* of Latreille most probably is referable to a distinct genus.

## CLASS IV.—INSECTA.

Insecta, so named from in *into*, and seco *to cut*. This term was applied to these animals by the Latins; by the Greeks they were named Entoma (ἔντομα), from ἐν, *into*; and τεμνω, *to cut*. Insects were so named, because their bodies are composed of many joints or segments, on which account several of the ancient and older naturalists placed them with the classes *Crustacea*, *Myriapoda*, *Arachnides*, and *Vermes*.

Insects constitute the most considerable portion of animated nature, on which account they become interesting, and very worthy of philosophic investigation; and consequently, from the earliest period, of which any authentic records remain, the study of them has obtained a very great portion of attention.

The oldest records on this subject are to be found in the sacred writings, where mention is made of locusts, flies, and caterpillars; and it is probable that Moses had acquired some knowledge of insects from the Egyptian sages, as his writings abound with passages relating to insects.

Hippocrates, as we are told by Pliny, wrote on insects, and the writings of the earlier Greek and Latin philosophers quoted by Pliny, afford extracts of his labours.

Aristotle, in his *History of Animals*, has devoted a very considerable portion of his attention to insects, which he called ἔντομα, and has described their general external structure with great accuracy; but we cannot enter into a detail of what was done by this great man, who has laid the foundation of the modern systems; and we must also pass over in silence, the little that has been observed by Ælian, Democritus, Aristamachus, and others of less note, and state generally that Pliny, in the eleventh book of his *Historia Naturalis*, treats of insects; but his observations are copies chiefly from the works of Aristotle. From the time of this author, until the overthrow of the Roman empire, the study seems to have been totally disregarded.

Sorry as we feel at being under the necessity of omitting to trace the rise of this interesting science, yet we shall give a sketch of the systems of every writer, that the rise of the *systematic* part may be rendered clear to every one interested with that branch of the science, which is the foundation on which the natural history is built.

Aldrovandus in 1602, published a very voluminous work, *De Animalibus Insectis*, in which he divides insects into *Terrestrial* and *Aquatic*.

In 1612, Woolfang Frenzius published *Historia Animalium Sacra*, which contains some new observations, and a distribution of insects into *Aërial*, *Aquatic*, and *Terrestrial*.

Swammerdam, who published his *Historia Insectorum Generalis* in 1669, divided genuine insects into, 1*st*, Those which, after leaving the egg, appear under the form of the perfect insect, but have no wings, which parts are afterwards produced; 2*dly*, Those insects which appear, when hatched from the egg, under the form of a larva (caterpillar), which, when full grown, changes into a chrysalis, where it remains until its parts are fit to be developed; 3*dly*, Those who, having attained the pupa (chrysalis or nympha) state, do not divest themselves of their skin. His other division refers to animals of the classes *Arachnides*, *Crustacea*, and *Myriapoda*, and the whole of his work contains much valuable observation on the structure and economy of these animals.

In 1735, Linné published the first edition of his *Systema Naturæ, sive Regna tria Naturæ Systematice proposita per classes, ordines, genera, et species*, in which work insects are distributed into four orders, according to the number and form of their wings.

1. Coleoptera.
2. Angioptera.
3. Hemiptera.
4. Aptera.

With the last order he included Crustacea, Arachnides, Myriapoda, Vermes, and certain Zoophytes; but in subsequent editions of this work, he separated the Vermes, as Aristotle had done before him, and established them as a class distinct from insects.

Schæffer in 1741 published a valuable work, under the title *Icones Insectorum circa Ratisbonam Indigenorum*. The classification proposed by this author differs entirely from that of Linné, and approaches in some respects that proposed by Geoffroy; yet it is so far distinct, that, being a system of considerable repute, it may not be amiss to give an outline of it in this place. He divides insects into seven Orders, which he terms Classes.

I. Coleoptero-macroptera. Insects with long crustaceous elytra.

II. Coleoptero-microptera. Insects with short crustaceous elytra.

III. Coleoptero-hymenoptera. Insects with half crustaceous elytra.

IV. Hymeno-Lepidoptera. Insects with transparent wings.

V. Hymeno-gymnoptera. Insects with naked membranaceous wings.

VI. Diptera. Insects with two wings.

VII. Aptera. Insects without wings, amongst which spiders, &c. were comprehended.

In 1764, Geoffroy published his most valuable system of insects, under the title, *Histoire Abrégée des Insectes*, &c. in which these animals are arranged into six sections:

I. Coleoptera. Wings covered with elytra; mouth with jaws.

II. Hemiptera. Upper wings resembling elytra; mouth bent under the thorax.

III. Tetraptera alis farinaceis. Wings four, covered by little scales.

IV. Tetraptera alis nudis. Wings four, naked, membranaceous.

V. Diptera. Wings two. Haltares or balancers, under the origin of the wings.

Insecta.

VI. Aptera. Wings none.

Like his predecessors, Geoffroy included Crustacea, &c. under the title Aptera.

In 1780, Linné produced the twelfth edition of his *Systema Naturæ;* and, as this was the last systematic work of that illustrious naturalist, we shall state his entomological arrangement. He divides insects into seven orders, deducing the characters from the wings, but he still retained the *Crustacea, Myriapoda*, and *Arachnides*, amongst the apterous insects.

Order I. Coleoptera (from κολεὸς, *a sheath*, and πτερὸν, *a wing*), including those insects having crustaceous shells or elytra, which shut together and form a longitudinal suture down the back. In many, the abdomen is wholly covered by these elytra; in others partially.

Order II. Hemiptera (from ἥμισυ, *half*, and πτερὸν). These animals have their elytra half crustaceous, and half membranaceous, or of a matter intermediate between leather and membrane.

Order III. Lepidoptera (from λεπὶς, *a scale*, and πτερὸν). Insects with four wings imbricated with scales.

Order IV. Neuroptera (from νεῦρον, *a nerve*, and πτερὸν). Insects with four transparent wings, reticulated with nerves.

Order V. Hymenoptera (from ὑμὴν, *a membrane*, and πτερὸν). Insects with four naked membranaceous wings.

Order VI. Diptera (from δυω, *two*, and πτερὸν). Insects with two wings.

Order VII. Aptera (from ἀ, without, and πτερὸν). Insects destitute of wings.

In 1776, J. C. Fabricius, a pupil of Linné, published a new system of entomology, under the title *Systema Entomologiæ*, in which the principles of a new mode of classification, founded on the organs of deglutition and mastication, is for the first time developed. This system, which has undergone several modifications, is named the *Cibarian System*, of which we shall say more, when speaking of the most improved form in which it has been given to the world.

Scopoli, in 1777, published his *Introductio ad Historiam Naturalem*, in which work he divides insects into five tribes, under the singular appellations of, 1. *Swammerdami-lucifuga*, 2. *Geoffroy-gymnoptera*, 3. *Roeselii-lepidoptera*, 4. *Reaumurii-proboscidea*, 5. *Frischii-Coleoptera;* identifying each tribe by the name of that author who has, in his opinion, been most successful in the explanation of that to which his name is attached.

The *Lucifuga* includes the lice; *Gymnoptera*, his *halterata*, *aculeata* and *caudata:* *Lepidoptera*, the moths and butterflies; *Proboscidea*, he has divided into terrestrial and aquatic, and the *Coleoptera* he divides into those inhabiting water, and those the land.

In 1793, P. A. Latreille published his *Precis du Caractéres des Genres*, in which he divided insects into, 1. *Coleoptera*, 2. *Orthoptera*, 3. *Hemiptera*, 4. *Neuroptera*, 5. *Lepidoptera*, 6. *Suctoria*, 7. *Thasynoura*, 8. *Parasita;* and under the further terms, *Acephala, Entomostraca, Crustacea, and Myriopoda*, he has comprehended the *Crustacea, Myriapoda*, and *Arachnides*.

Insecta.

In 1798, J. C. Fabricius produced his last general systematic work, his *Supplementum Entomologiæ Systematicæ*, which presents an outline of his system in its latest state; and which, being the result of much knowledge, demands a considerable portion of attention. In this work he divides genuine insects into the following Orders, which he named Classes. The omitted classes are referable to Crustacea, Myriapoda, and Insecta, as already shown.

Class I. Eleuterata. Maxillæ naked, free, bearing palpi.

Class II. Ulonata. Maxillæ covered by an obtuse galea, or mouth-piece.

Class III. Synistata. Maxillæ elbowed at their base, and connected with the labium.

Class IV. Piezata. Maxillæ corneous, compressed, often elongate.

Class V. Odonata. Maxillæ corneous, dentated. *Palpi* two.

Class XI. Glossata. Mouth with a spiral tongue reflexed between the palpi.

Class XII. Ryngota. Mouth with a rostrum and articulated sheath.

Class XIII. Antliata. Mouth with an inarticulate haustellum.

In the "*Entomologie Helvetique*," a work published in 1798, Clairville, its author, has arranged insects in the following manner:

* PTEROPHORA; mandibulata. With wings and jaws.

Section 1. Elytroptera. Wings crustaceous.
2. Deratoptera. Wings coriaceous.
3. Dictyoptera. Wings reticulated.
4. Phleboptera. Wings veined.

** PTEROPHORA; haustellata. With wings and an haustellum.

5. Halteriptera. Wings with poisers.
6. Lepidoptera. Wings with powder.
7. Hemimeroptera. Wings partly obscure, partly diaphanous.

*** APTERA; haustellata. Without wings; with a sucker.

8. Rophoptera. Sucker sharp.

**** APTERA; mandibulata. Without wings; with jaws.

9. Pododunera. Legs formed for running.

In 1800, Cuvier, with the assistance of Duméril, published his *Anatomie Comparée*, in which the organization of insects is treated of at great length.

In 1801, J. B. Lamarck produced his *Systême des Animaux sans Vertèbres*, in which work he has separated the Crustacea from Insects, and proposed the Arachnides as a separate and distinct class. Some of the animals which we conceive to be genuine insects, he has placed with the Arachnides, the rest he distributes into the following Orders:

* *With mandibles and jaws.*

Order I. Coleoptera. Two wings, folded transversely, and covered by coriaceous elytra.

Order II. Orthoptera. Two strait wings, folded longitudinally, and covered by submembranaceous cases, or elytra.

Order III. Neuroptera. Four naked, reticulated, membranaceous wings.

** *With mandibles and with a kind of proboscis.*

Order IV. Hymenoptera.

*** *No mandibles. A trunk or sucker.*

Order V. Lepidoptera. Four membranaceous wings covered with fine powder-like scales; tongue spiral.

Order VI. Hemiptera. Two wings, covered by semimembranaceous elytra.

Order VII. Diptera. Two naked wings, with balancers at their base.

Order VIII. Aptera. No wings. Mouth with an articulated trunk.

In the same year, in 1806, P. A. Latreille published his *Genera Crustaceorum et Insectorum*, in which he has denominated the true insects *Insecta Pterodicera*; and has arranged them in the following manner:

Century I. ELYTHROPTERA.

Elytra two, covering the wings entirely.

Cohors I. Odontota.

Mouth with mandibles, maxillæ, and lip. Wings folded.

Order I. Coleoptera. Wings transversely folded. Elytra crustaceous.

Order II. Orthoptera. Wings longitudinally folded. Elytra coriaceous.

Cohors II. Siphonostoma.

Order III. Hemiptera. Mouth with an articulated beak, sheathing the haustellum, formed of three setæ. Wings extended; elytra generally semicoriaceous or semimembranaceous, one decussating the other.

Century II. Gymnoptera.

Wings naked.

Cohors I. Odontota.

Mouth with mandibles, maxillæ, and lip. Wings four.

Order IV. Neuroptera. Wings reticulated, most generally equal. Maxillæ not sheathing the sides of the lip.

Order V. Hymenoptera. Wings veined, hinder ones smallest. Maxillæ sheathing the sides of the lip.

Cohors II. Siphonostoma.

Mouth tubular, formed for sucking.

Order VI. Lepidoptera. Wings four, imbricated with scales. Mouth with a spiral tongue, formed of two laciniæ; haustellum none.

Order VII. Diptera. Wings two, with haltares or balancers at their base. Mouth with a proboscis, including an haustellum that is composed of one part, or at least only geniculated at its base.

Order VIII. Suctoria. Wings and balancers none. Body formed of a series of rings. Thorax not distinct from the base of the abdomen. Mouth with a rostrum articulated from its origin, with two external valves at the base.

Latreille has retained the same general arrangement in his last work, *Considerations Génerales sur l'Ordre Naturelle, &c.* but he has rejected the divisions into legions, centuries, and cohortes.

Duméril, in his *Zoologie Analytique*, arranges insects into eight orders, the last of which also comprehends the classes Arachnides and Myriapoda.

In 1812, De Lamarck published a little work, entitled *Extrait de Cours de Zoologie du Muséum d'Histoire Naturelle*, in which he has continued the general arrangement published by him in 1801.

In 1815, Vol. IX. of the *Edinburgh Encyclopædia* was published, in which Dr Leach has given the following arrangement of insects into orders, and has added to them the *Parasita* and *Thysanoura*, which Latreille placed with the Arachnides.

INSECTA.

Subclass I. AMETABOLIA.

Insects undergoing no metamorphosis.

Order I. Thysanura. Tail armed with setæ.

Order II. Anophura. Tail without setæ.

Subclass II. METABOLIA.

Insects undergoing metamorphosis.

Century I. ELYTHROPTERA.

Insects with elytra.

Cohors I. Odontostomata.

Mouth with mandibles.

* *Metamorphosis incomplete.*

Order III. Coleoptera. Wings transversely folded. Elytra crustaceous, covering the wings, their suture strait.

** *Metamorphosis nearly coarctate.*

Order IV. Strepsiptera. Wings longitudinally folded. Elytra coriaceous, not covering the wings.

*** *Metamorphosis semi-complete.*

Order V. Dermaptera. Wings longitudinally and transversely folded. Elytra somewhat crustaceous, abbreviated, with the suture strait.

Order VI. Orthoptera. Wings longitudinally folded. Elytra coriaceous, the internal margin of one elytron covering the same part of the other.

Order VII. Dictyoptera. Wings longitudinally folded twice or more. Elytra coriaceous, nervose, one decussating the other obliquely.

Cohors II. Siphonostomata.

Mouth with an articulated rostrum.

Order VIII. Hemiptera. Elytra somewhat crustaceous, or very coriaceous; towards the apex generally membranaceous, horizontal, one decussating the other obliquely. (Metamorphosis semi-complete.)

Order IX. Omoptera. Elytra entirely coriaceous, or membranaceous, and meeting obliquely, with a strait suture. (Metamorphosis semi-complete, or incomplete.)

Century II. MEDAMOPTERA.

Insects without wings or elytra.

Order X. Aptera. Mouth with a tubular sucking rostrum. (Metamorphosis incomplete.)

Century III. GYMNOPTERA.

Insects with wings, but with no elytra.

Cohors I. Glossostomata.

Mouth with a spiral tongue.

Order XI. Lepidoptera. Wings four, imbricated with scales.

Cohors II. Gnathostomata.

Mouth with maxillæ and lip.

Insecta.

Order XII. Trichoptera. Wings four, membranaceous, the pterygostia hairy.

Cohors III. Odontostomata.

Mouth with mandibles, maxillæ, and lip.

Order XIII. Neuroptera. Four highly-reticulated wings, generally of an equal size. (Anus of the female without a sting, or compound oviduct.)

Order XIV. Hymenoptera. Four venose wings, hinder ones smallest. (Anus of the female with a sting, or compound oviduct.)

Cohors IV. Siphonostomata.

Mouth tubular, formed for sucking.

Order XV. Diptera. Wings two, with balancers at their base.

The above arrangement is liable to various objections. We shall endeavour to define the orders in a more intelligible and simple manner.

*Classification.*

All genuine insects have six legs; a head distinct from their body, and furnished with two antennæ: they all are produced from eggs. Some undergo no metamorphosis, others but a partial change, whilst the remainder pass through three stages of existence, after having been hatched from the egg.

The peculiarities of every order will be mentioned under its proper head, in the article Insecta; but we shall here proceed with the systematic arrangement into orders.

Subclass I. AMETABOLIA.

Insects undergoing no metamorphosis.

Order I. Thysanoura. Tail armed with setæ.

Order II. Anoplura. Tail without setæ.

Subclass II. METABOLIA.

Insects undergoing metamorphosis.

Order III. Coleoptera. Wings two, transversely folded, covered by two crustaceous or hard coriaceous elytra, meeting (generally) with a strait suture. Mouth with mandibles. (Metamorphosis incomplete.) Plate XXIV.

Order IV. Dermaptera. Wings two, longitudinally and transversely folded. Elytra subcrustaceous, abbreviated, with the suture strait. Mouth with mandibles. (Metamorphosis semi-complete.) Plate XXIV.

Order V. Orthoptera. Wings two, longitudinally folded, covered by two coriaceous elytra, the margin of one elytron covering the same part of the other. Mouth with mandibles. (Metamorphosis semi-complete.) Plate XXIV.

Order VI. Dictyoptera. Wings two, longitudinally folded, twice or more, covered by two coriaceous elytra, one elytron decussating the other obliquely. Mouth with mandibles. (Metamorphosis semi-complete.) Plate XXIV.

Order VII. Hemiptera. Wings two, covered by two crustaceous or coriaceous elytra (the tips of which are generally membranaceous), horizontal, one decussating the other obliquely. Mouth with an articulated rostrum. (Metamorphosis semi-complete.) Plate XXIV.

Order VIII. Omoptera. Wings two, covered by two elytra, which are entirely coriaceous or membranaceous; meeting obliquely with a strait suture. Mouth with an articulated rostrum. (Metamorphosis semi-complete, or incomplete.) Plate XXIV.

Order IX. Aptera. No wings, or elytra. Mouth with a tubular, jointed, sucking rostrum. (Metamorphosis incomplete.)

Order X. Lepidoptera. Wings four, membranaceous, covered with meal-like scales. Mouth with a spiral tongue. (Metamorphosis incomplete.) Plate XXV.

Order XI. Trichoptera. Wings four, membranaceous; the pterigostia or wing-bones hairy. Mouth with maxillæ and lip. (Metamorphosis incomplete.) Plate XXV.

Order XII. Neuroptera. Wings four, membranaceous, generally of equal size; with numerous decussating pterigostia, resembling a net-work. Mouth with mandibles, maxillæ, and lip. (Metamorphosis incomplete or semi-complete.) Plate XXV.

Order XIII. Hymenoptera. Wings four, membranaceous, the hinder ones always smallest; the pterigostia not decussating each other, so as to resemble a net-work. Mouth with mandibles, maxillæ, and lip. (Metamorphosis incomplete.) Plate XXV.

Order XIV. Strepsiptera. Wings two, longitudinally folded. *Mouth* with mandibles. (Metamorphosis subcoarctate.) Plate XXIV.

Order XV. Diptera. *Wings* two, with haltares or balancers at their base. Mouth tubular, formed for sucking. (Metamorphosis incomplete or subcoarctate.) Plate XXV.

The generic characters of insects, and their distribution into families and stirpes, will be given under the article Insecta, which see.

## CLASS V.—Vermes.

Vermes.

The Vermes comprehend all those annulose animals which have no distinct head, no antennæ, and no legs. Many of them inhabit the sea, others fresh water, and some few damp places, or even under the earth. Their classification is not understood; an extensive field is therefore open to any naturalist, who may hereafter have time, inclination, and opportunity to study them.

Lamarck and others have arranged them, from the position of their respiratory organs, into two orders, which we have adopted; but the arrangement of the genera appears to be very artificial, although well calculated to assist the views of the student.

Order I. Cryptobranchia. Organs of respiration concealed, or internal.

Order II. Gymnobranchia. Organs of respiration naked, or external.

Order I. Cryptobranchia.

A. *Body* rounded, furnished with little spines.

Genus 1. Lumbricus, 2. Thalessema.

B. *Body* rounded or flattened; each extremity furnished with a sucker.

Genus 3. PONTOBDELLA, 4. HIRUDO.

C. *Body* flattened, naked, smooth; extremities without suckers.

Genus 5. PLANARIA.

D. *Body* flattened; sides with setæ.

Genus 6. NAÏS.

A.

Gen. 1. LUMBRICUS *of authors.*

*Body* naked, long, cylindric, articulated; rings fleshy, contractile; with short fasciculæ of spines; anterior extremity conic; posterior extremity somewhat flattened, obtuse.

One species only has been accurately determined by naturalists. This species is hermaphrodite, and deposits its eggs. There is an excellent paper on its structure, by De Montegre, published in the first volume of the *Mémoirs du Muséum d'Histoire Naturelle.*

Sp. 1. *Terrestris* of authors. Plate XXVI.

This is the common earth-worm, whose use, in the economy of nature, seems to be, that of rendering the earth more porous, by its innumerable holes, and thus facilitating the growth of vegetables, which it manures by the leaves, &c. that it draws into its haunts.

Gen. 2. THALESSEMA. *Cuvier,* &c.

*Body* with its hinder extremity much thicker than the anterior, which resembles a conic funnel; neck with two hooks below.

The *Thalessemæ* inhabit the shores of the sea.

Sp. 1. *Aquatica.*

B.

The animals of this section are denominated *Leeches* or *Blood-suckers.* One of the genera inhabits the sea, the other fresh-water.

Gen. 3. PONTOBDELLA. *Leach.* (SEA-LEECH.)

*Body* oblong, round, slightly contractile; both extremities (especially the anterior extremity) attenuated; skin subcoriaceous.

Sp. 1. *Spinulosa.* Body Spinulose.

Plate XXVI.

This species is common in the North British seas, adhering to skates, whence it is commonly called *skate-sucker.* When bruised it emits a dark liquor, which stains of a beautiful purple colour.

Gen. 4. HIRUDO *of authors.* (LEECH.)

*Body* oblong, more or less flattened, very contractile; anterior extremity very gradually attenuated; skin tough.

Sp. 1. *Medicinalis.* (Common leech.)

Plate XXVI.

This species inhabits rivers and lakes. It is the common leech used by medical people.

C.

Gen. 5. PLANARIA. *Müll.* &c.

*Body* horizontally depressed, subgelatinous; *mouth* terminal; *belly* with two openings beneath; one for generation; the other for the passage of the excrement.

The species are numerous, and of various shapes: They inhabit fresh waters; some have one, two, three, four, or even no eyes; some have tentacules, others none. On this account, as Cuvier observes, they should be distributed under several generic heads.

D.

Gen. 6. NAÏS. *Müller,* &c.

*Body* naked, long, slender, somewhat depressed, articulated; *sides* with long setæ, disposed in bundles.

Sp. 1. *Proboscidea.* Reddish, mouth produced, filiform.

Inhabits fresh waters. Its mode of generation is curious. The last joint of the body by degrees separates and forms an entire animal.

OBS. The other *Naides* of authors (at least those whose economy is known) deposit eggs. This genus may therefore be divided hereafter, when the exact structure of each species shall have been accurately determined.

Order II. GYMNOBRANCHIA.

A. *Body* free.

a. *Mouth with jaws.*

Genus 7. NEREIS.

b. *Mouth without jaws; labial palpi distinct.*

Genus 8. AMPHINOME, 9. APHRODITA, 10. LEPIDONOTUS.

c. *Mouth without jaws; labial palpi none.*

Genus 11. ARENICOLA.

B. *Body* inclosed within a tube.

a. *Tube composed of fragments of shell or sand; head with tentacules.*

Genus 12. TEREBELLA, 13. AMPHITRITE.

b. *Tube composed of fragments of shell or sand; head without tentacules.*

Genus 14. CISTENA.

c. *Tube testaceous, open at each end.*

Genus 15. DENTALIUM.

d. *Tube testaceous, open at its anterior end only.*

Genus 16. SERPULA, 17. SPIRORBIS.

A. a.

Gen. 7. NEREÏS *of authors.*

*Body* composed of rings; rings on each side with processes of various forms in the different species. *Mouth* with tentacules.

The Nereïdes are often called *Sea-centipieds,* from their general resemblance to the Scolopendridea. They require to be investigated. Their tentacules vary in number, in proportion, and in situation. The characters for division are therefore very obvious. Their mouth varies very much in the structure of its parts, in the size of its jaws, in the form of the lateral processes, &c.

Sp. 1. *Margaritacea.* Body pearly; terminated by two long setæ; tentacules eight; head trilobate; exterior lobes, with their points attenuated and very slightly knobbed; middle lobe with two little incurved processes.

Plate XXVI.

This species is common at the Bell-Rock, and is subject to great variation in colour; being sometimes greenish-bronze, at other times with a purple line running down the middle of its back.

A. b.

The three genera of this division form a natural group.

Vermes.

Gen. 8. Amphinome. *Bruguière, &c.*

*Organs of respiration* long, plumose.

Sp. 1. *Tetraedra.*

Aphrodita rostrata. *Pallas.*

Gen. 9. Aphrodita *of authors.*

*Organs of respiration* short, covered. *Back* membranaceous, naked; *sides* very bristly; bristles intermingled with silky down.

Sp. 1. *Aculeata* of authors.

Inhabits the European Ocean. It is often named the sea-mouse by our fishermen.

Gen. 10. Lepidonotus, new genus.

*Organs* of respiration short, covered. *Back* covered by a double series of scales.

This genus contains many species: We possess about eleven kinds found on our coasts.

Sp. 1. *Clavatus.*

Aphrodita clava.

*Montagu, Trans. Linn. Soc.* ix. tab. 7.

Inhabits the British Seas.

A. c.

Gen. 11. Arenicola. *Lamarck, &c.*

*Body* round, each extremity rounded, obtuse; *posterior extremity* narrowest; *anterior extremity* with tubercles on each side terminated by setæ; *organs of respiration* placed externally behind the tubercles of the middle of the body.

Sp. 1. *Carbonaria.* Body coal-black.

Inhabits the Firth of Forth at the Black Rocks, near Leith, under stones. Plate XXVI.

Sp. 2. *Tinctoria.* Body yellowish inclining to cinereous, beautifully banded with blue; organs of respiration blood-red; tail greenish.

Inhabits the sand of the sea, in which it burrows, and is extracted by the fishermen, who use it as a bait for fish. When living the tail secretes a fluid which stains the fingers of a fine yellow colour.

Lumbricus marinus of Linné belongs to this genus, of which we possess two other indigenous species.

B. a.

Gen. 12. Terebella. *Linné, &c.*

*Body* cylindric. *Tentacules* capillary, numerous.

This genus has been confused with Amphitrite, by several authors. The Linnean character "tentacula capillaria" will however apply to this alone.

Sp. 1. *Lapidaria.* Linné.

Inhabits the Mediterranean.

Gen. 13. Amphitrite. *Müller, &c.*

*Body* annulated. *Tentacules* acuminate, plumose, numerous.

Vermes.

Sp. 1. *Volutacornis.* Tentacules convoluted; stem with long ciliated fibres on one side, spirally turned two or three times.

Amphitrite volutacornis.

*Montagu, Trans. Linn. Soc.* xi. 81. tab. 7. fig. 10.

Inhabits the southern coast of Devon, where it was first discovered by Montagu. Plate XXVI.

B. b.

Gen. 14. Cistena, new genus.

*Mouth* with two pectinated scales, of a brilliant golden colour. Plate XXVI.

Sp. 1. *Pallassii.*

Nereis cylindraria.

*Pall. Miscel. Zool.* 181. tab. ix. fig. 3.

Sabella tubiformis.

*Penn. Brit. Zool.* iv. 148. tab. 92. fig. 163.

Nereis conchilega.

*Penn. Brit. Zool.* iv. 47.

Inhabits the sandy shores of Britain.

B. c.

Gen. 15. Dentalium *of authors.*

*Head* with tentacules. *Tubes* slightly bent.

The species of this genus are distinguished by the sculpture of their shelly tubes.

Sp. 1. *Entalis* of authors.

Inhabits the European Ocean.

B. d.

Gen. 16. Serpula *of authors.*

*Tentacules* forming two bundles.

The species of this genus are very numerous, and are but little known; they are to be distinguished by their shelly tubes.

Gen. 17. Spirorbis. *Daudin, &c.*

*Tentacules* six in number, resembling palpes.

The *Spirorbes* form an extensive genus, the species of which are distinguished by their shells.

The classification of the *Vermes*, as we have before observed, is so very imperfectly understood, that the above enumeration of the genera can be of use only to the student.

The other genera formed by Montagu and Fleming, will be given in the article Zoology, their situation in the system not having been determined by an examination of the animals. (v.)

## INDEX OF GENERA.

# ANNULOSA.

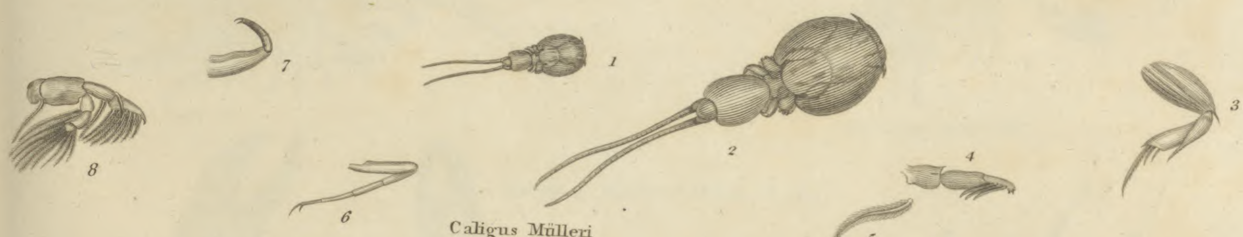
PLATE XX.

Class CRUSTACEA.

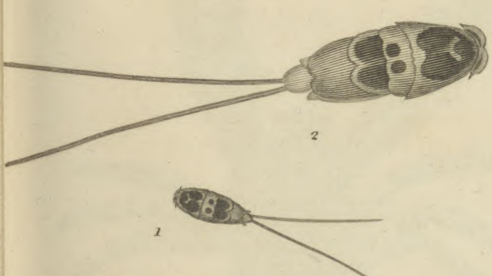
Sub Clafs *ENTOMOSTRACA.*


Cecrops Latreillii


Anthosoma Smithii



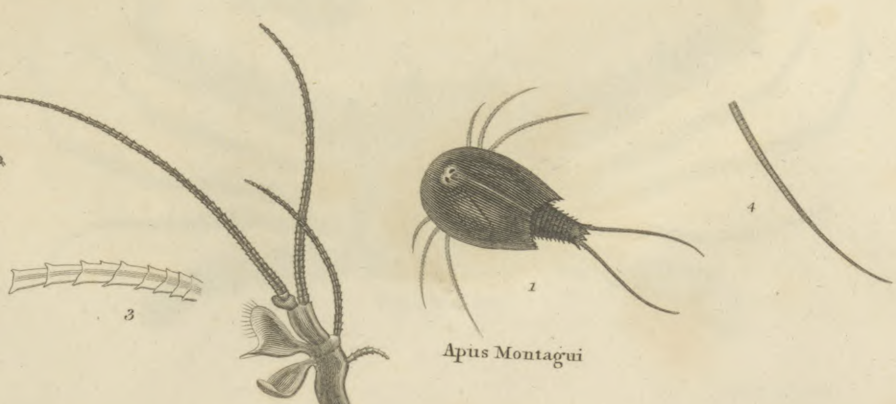

Caligus Mülleri




Pandarus bicolor


Pandarus Boscii


Cypris nephröides




Apus Montagui

## ANNULOSA. PLATE XXI.

Claſs CRUSTACEA. Sub-claſs MALACOSTRACA.

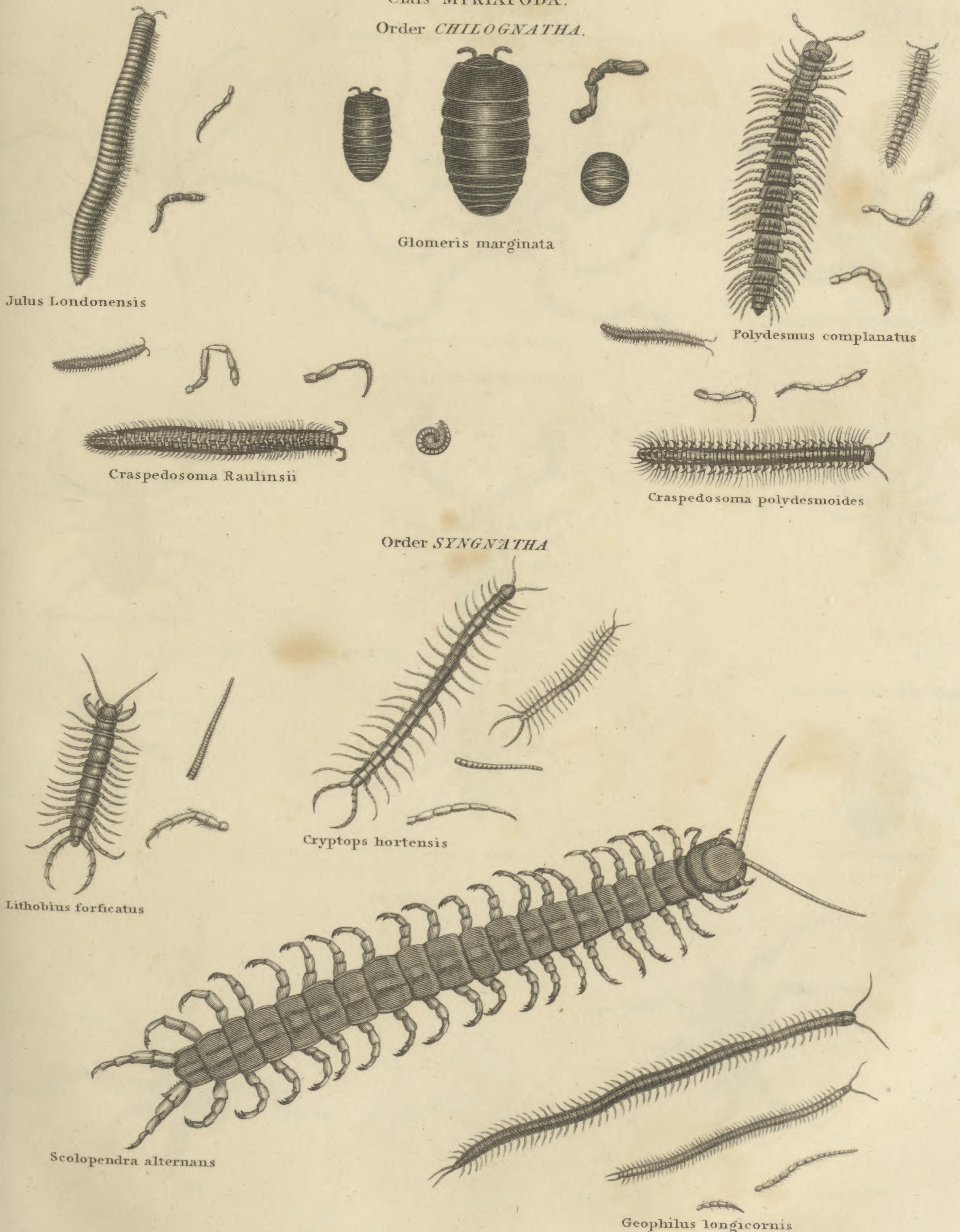
Legion *EDRIOPHTHALMA*.


H. Weddell Sculp.t

ANNULOSA. 

Clafs MYRIAPODA.

Order *CHILOGNATHA*.




*J. Sowerby del.* *H. Weddell Sculp.*

ANNULOSA. PLATE XXIII.

Clafs ARACHNIDES. Sub-Clafs CEPHALOSTOMATA.

Order *PODOSOMATA*.

Nymphum Gracile.

Ammothea Carolinensis.

Pycnogonum Balænarum.

Order *POLYMEROSOMATA*.

Obisium Trombidioides.

Chelifer fasciatus.

Siro Rubens.

Order *DIMEROSOMATA*.

Dysdera erythrina.

Atypus Sulzeri.

Order *MONOMEROSOMATA*.

Argas reflexus.

Sub-Clafs *NOTOSTOMATA*.

Phthiridium Hermanni.

H. Weddell. Sculp.

*Published by A. Constable & Co. 1816.*

ANNULOSA.



Class INSECTA

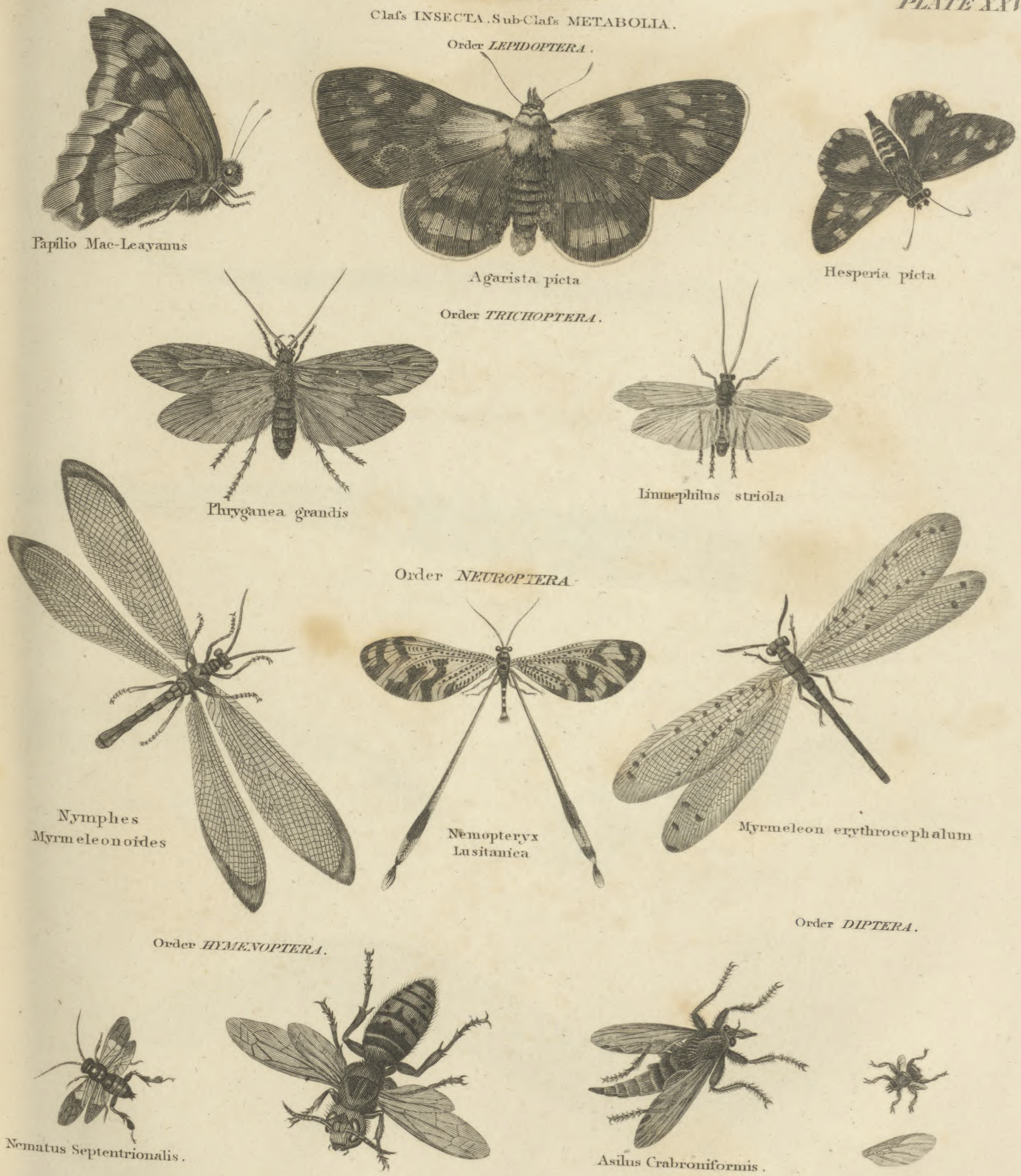
Sub-Class *AMETABOLIA*


Published by A. Constable & Co. 1816

ANNULOSA.

Clafs INSECTA. Sub-Clafs METABOLIA.

*PLATE XXV.*



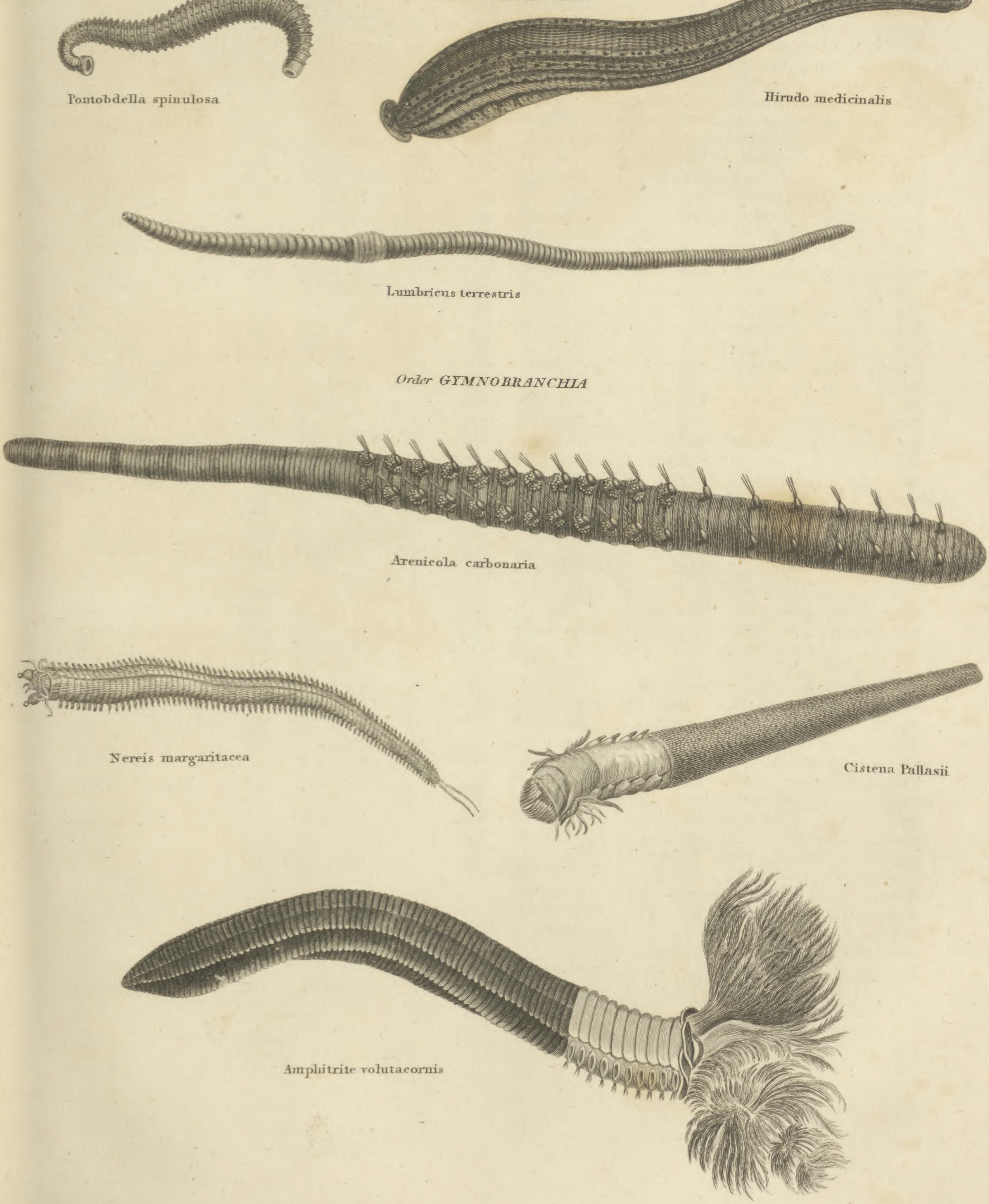

*Published by A.Constable & Co. 1816.*

*W. Weddell Sculp*

# ANNULOSA.

Class VERMES.

*Order CRYPTOBRANCHIA.*




*Published by A. Constable & Co. 1816.*

*Milton sculp.*

Anquetil.

ANQUETIL (LEWIS PETER), a French historian, was born at Paris, on the 21st of January 1723. At the age of seventeen, he entered the congregation of St Genevieve, where he taught theology and literature with ability and success. He afterwards became Director of the academy at Rheims; and, in 1759, he was appointed Prior of the abbey de la Röe, in Anjou. Soon after this, he was sent, in the capacity of Director, to the college of Senlis. In 1766, he obtained the Curacy or Priory of Chateau-Renard, near Montargis, which he exchanged, at the commencement of the Revolution, for the Curacy of La Villette, in the neighbourhood of Paris. During the reign of terror, he was imprisoned at St Lazare. On the establishment of the National Institute, he was elected a member of the second class, and was soon afterwards employed in the office of the minister for foreign affairs. Endowed with a robust constitution, which was preserved by a natural equality of temper, and general moderation in diet, Anquetil was capable of very laborious exertions, and is said to have passed ten hours every day, regularly, in study. When upwards of eighty, he still meditated extensive literary undertakings; but he was carried off by death, in the midst of his projects and researches, on the 6th of September 1808, in the eighty-fourth year of his age. On the evening previous to this event, he is reported to have said to one of his friends, "Come and see a man who is dying full of life."

As an author, M. Anquetil does not stand very high in the ranks of literature. He possessed more industry in research, than ability or judgment in execution. His style is censurable in many respects, and he appears to have been almost entirely destitute of the critical discernment and philosophical sagacity, which are requisite to form the character of a good historian. The following is a list of his principal works. 1. *Histoire Civile et Politique de la ville de Reims*, 1756-57, 3 vols. 12mo. The history is brought no farther down than 1657; a fourth volume should have been added, but it never appeared. Anquetil is said to have written this work in concert with one Felix de la Salle, and it is, perhaps, the best of all his productions. 2. *Almanach de Reims*, 1754, in 24mo. 3. *L'Esprit de la Ligue, ou Histoire Politique des Troubles de France, pendant les 16 et 17 siècles*, 1767, 3 vols. 12mo. This work has been frequently reprinted. 4. *Intrigue du Cabinet sous Henri IV. et sous Louis XIII. terminée par la Fronde*, 1780, 4 vols. 12mo. 5. *Louis XIV. sa Cour et le Regent*, 1789, 4 vols. 12mo; reprinted in 1794, 5 vols. 12mo. 6. *Vie du Marechal Villars, ecrit par lui-même, suivie de Journal du la Cour de 1724 à 1734*, Paris, 1787, 4 vols. 12mo; reprinted in 1792. 7. *Precis de l'Histoire Universelle*, 1797, 9 vols. 12mo; reprinted in 1801 and 1807, in 12 vols. 12mo. This work has been translated into English, Spanish, and Italian. 8. *Motifs des Guerres et des Traités de Paix de la France, pendant les regnes de Louis XIV. Louis XV. et Louis XVI.* 1798, 8vo. 9. *Histoire de France, depuis les Gaules jusqu' à la fin de la Monarchie*, 1805 *et seqq.* 14 vols. 12mo. This work was composed in haste, and is of no great value. 10. *Notice sur la vie de M. Anquetil du Perron.* M. Anquetil likewise wrote several papers in the Memoirs of the Institute. See *Biographie Universelle*. (H.)

Anquetil. Du Perron.

ANQUETIL DU PERRON (ABRAHAM HYACINTH), brother of the subject of the preceding article, was born at Paris, on the 7th of December 1731. Having distinguished himself as a student at the university of that city, and acquired a considerable knowledge of the Hebrew language, he was invited to Auxerre by M. de Caylus, then the Bishop of that diocese. This prelate made him study theology, first at the academy of his diocese, and afterwards at that of Amersfort, near Utrecht; but Anquetil had no desire to embrace the ecclesiastical vocation, and devoted himself with ardour to the study of the different dialects of the Hebrew, and of the Arabic and Persian. Neither the solicitations of M. de Caylus, nor the hopes of rapid preferment, had the power to detain him at Amersfort, after he thought he had acquired every thing that was to be learnt there. He returned to Paris, where his diligent attendance at the Royal Library, and his ardour in the prosecution of his favourite studies, attracted the attention of the Abbé Sallier, keeper of the manuscripts, who introduced him to the acquaintance of his associates and friends, whose united exertions procured for him a small salary, as student of the oriental languages. He had scarcely received this appointment, when, having accidentally laid his hands on some manuscripts in the *Zend*, he formed the project of a voyage to India, with the view of discovering the works of Zoroaster. At this period, an expedition was preparing at the port of L'Orient, which was destined for India. M. du Perron, however, applied in vain, through his protectors, for a passage; and seeing no other means of accomplishing his plan, he enlisted as a common soldier, and set out from Paris, with a knapsack on his back, on the 7th of November 1754. His friends procured his discharge; and the minister, affected by this romantic zeal for science, granted him a free passage, a seat at the captain's table, and a salary, the amount of which was to be fixed by the governor of the French settlements in India. After a passage of nine months, Anquetil landed, on the 10th of August 1755, at Pondicherry. Here he remained no longer than was necessary to make himself master of the modern Persian, and then hastened to Chandernagore, where he thought to acquire the Sanscrit. But in this he was deceived; and he was on the point of returning, when a serious complaint threatened his life. He had scarcely escaped from this danger, when war was declared between France and England; Chandernagore was taken; and Anquetil resolved to return to Pondicherry by land. After a journey of one hundred days, in the course of which, he encountered many adventures, and suffered many hardships, he arrived at Pondicherry. Here he found one of his brothers who had arrived from France, and embarked with him for Surat; but, with the view of exploring the country, he landed at Mahe, and proceeded on foot. It was at Surat that he succeeded, by perseverance and address in his intercourse with the native Priests, in acquiring a sufficient knowledge of the languages, to enable him to translate the Dictionary,

Anquetil Du Perron.

called the *Vedidad-Sade*, and some other works. From thence he proposed going to Benares, to study the languages, antiquities, and sacred laws of the Hindoos; but the capture of Pondicherry obliged him to return to France. He accordingly embarked on board an English vessel, and landed at Portsmouth, in the month of November 1761. After spending some time in London, and visiting Oxford, he set out for Paris, where he arrived on the 4th of May 1762, without fortune, or the desire of acquiring any; but esteeming himself rich in the possession of an hundred and eighty oriental manuscripts, besides other curiosities. The Abbé Barthelemy, and his other friends, procured for him a pension, with the title and appointments of Interpreter for the oriental languages at the royal library. In 1763, the Academy of the *Belles Lettres* received him among the number of its associates; and from that period, he devoted himself to the arrangement and publication of the materials he had collected during his eastern travels. In 1771, he published a work in three volumes 4to, under the title of *Zend-Avesta*, containing collections from the sacred writings of the Persians, among which are fragments of works ascribed to Zoroaster; and he accompanied this work with an account of the life of that sage. This publication must be considered as constituting a very important accession to our stores of oriental literature. A recent historian, and very competent judge, refers to the *Zend-Avesta*, as certainly the most authentic source from which we can derive information regarding the religion and institutions of the great Persian legislator. (Sir John Malcolm's *Hist. of Persia*, Vol. I. p. 193, Note.) To the *Zend-Avesta* M. Du Perron prefixed a discourse, in which he treated the University of Oxford, and some of its learned members, with ridicule and disrespect. Mr (afterwards Sir William) Jones replied to these invectives in an anonymous letter, addressed to the author, written in French, with uncommon force and correctness of style, but at the same time, with a degree of asperity which could only be justified by the petulance of M. Du Perron. In 1778, he published his *Legislation Orientale*, in 4to; a work in which he controverts the system of Montesquieu, and endeavours to prove, that the nature of oriental despotism has been misrepresented by most authors; that in the empires of Turkey, Persia, and Hindostan, there are codes of written law, which equally bind the prince and subject; and that, in these three empires, the inhabitants possess both moveable and immoveable property, which they enjoy with perfect security. His *Recherches Historiques et Geographiques sur l'Inde*, appeared in 1786, and formed part of Thieffenthaler's *Geography of India*. They were followed, in 1789, by his treatise *De la Dignité du Commerce et de l'etat du Commerçant*. The Revolution seems to have greatly affected him. During that period, he abandoned society, shut himself up in his study, and devoted himself entirely to literary seclusion. In 1798, he published *L'Inde en Rapport avec l'Europe*, &c. in 2 vols. 8vo; a work which is more remarkable for its virulent invectives against the English, and for its numerous misrepresentations, than for the information which it contains, or the soundness of the reflections which it conveys. The spirit of the work, indeed, may be ascertained from the summary of its contents, stated in the title-page, in which the author professes to give a detailed, accurate, and terrific picture of the English Machiavelism in India; and he addresses his work, in a ranting, bombastic dedication, to the *Manes* of Dupleix and Labourdonnais. In 1804, he published a Latin translation from the Persian of the *Oupnek'hat*, or *Upanischada*, i. e. "Secrets which must not be revealed," in 2 vols. 4to. On the re-organization of the Institute, M. Anquetil was elected a member, but soon afterwards gave in his resignation. He died at Paris on the 17th of January 1805.

Anquetil Du Perron || Ant.

Besides the works we have already enumerated, M. Anquetil read to the Academy several memoirs on subjects connected with the history and antiquities of the East. At the time of his death, he was engaged in revising a translation of the *Travels of Father Paulin de St Barthelemy in India;* which work was continued by M. Silvestre de Sacy, and published in 1808, in 3 vols. 8vo. He also left behind him a great number of manuscripts, among which, his biographers particularly notice the translation of a Latin treatise *on the Church*, by Doctor Legros, in 4 vols. 4to.

From the preceding narrative, our readers will be enabled to form some notion of the character of Anquetil Du Perron. Among his countrymen, he is regarded as one of the most learned men of the eighteenth century. He certainly distinguished himself by a very ardent and disinterested zeal in the prosecution of those studies to which he dedicated the labours of a long life; but the lustre of his literary character was obscured by a very absurd vanity, and the most inveterate prejudices. In a Discourse addressed to the Asiatic Society at Calcutta, in 1789, Sir William Jones speaks of him, as "having had the merit of undertaking a voyage to India, in his earliest youth, with no other view than to recover the writings of Zeratust (Zoroaster), and who would have acquired a brilliant reputation in France, if he had not sullied it by his immoderate vanity and virulence of temper, which alienated the good-will even of his own countrymen." In the same Discourse, he affirms, that M. Anquetil most certainly had no knowledge of the Sanscrit.—See *Biographie Universelle. Monthly Rev.* Vol. LXI. Lord Teignmouth's *Life of Sir William Jones*. (II.)

Progress of this branch of Entomology.

ANT. The history of a tribe of insects so long celebrated for their industry and frugality, and for the display of that sagacity which characterizes some of the higher orders of animals, is peculiarly calculated to occupy the attention of modern naturalists. The ancients, indeed, had often noticed the habits and economy of the ant; but their accounts, at all times deficient in accuracy from the want of precise definitions and logical arrangement of the objects they describe, are, in this instance, so mixed up with fanciful notions, and chimerical doctrines, and so coloured by the vivid imagination and credulity of the narrators, as to have retarded rather than advanced the progress of real knowledge. Aristotle and Pliny report, for instance, that the labours of ants are in a great measure regulated by the phases

Ant.

of the moon; and the latter mentions a species found in the northern parts of India, whose size was said to equal that of the wolves of Egypt, whose colour was the same as that of a cat, and whose occupation in winter consisted in digging up gold from the bowels of the earth; while the inhabitants in the summer, robbed them of their treasures, after having decoyed them, by stratagem, from their nests. Great mistakes have prevailed, even in later times, from the circumstance of the larvæ of ants bearing a resemblance to grains of corn, which it was supposed these insects hoarded up as a provision for winter consumption. The form of the eggs and of the larvæ, and the attention paid to them by the ants, were described by Dr King in the 23d Number of the *Philosophical Transactions*; but Leuwenhoeck was the first who distinguished, with precision, the different forms which the insect assumes in the several stages of its growth. He traced the successive changes from the egg to the larva, the nymph, and the perfect insect. Swammerdam pursued his scrutiny into these successive developements with greater minuteness; and, unrivalled in the act of microscopic dissection, discovered the wonderful encasement of all the parts of the future ant, at every preceding stage; and showed that it appears under such different forms only from the nature of its envelopes, each of which, at the proper period, is in its turn cast off. Linnæus (*Memoirs of the Royal Academy of Sciences at Stockholm*, Vol. II.) ascertained some of the leading facts with regard to the distinction between the sexes, and determined that the ants which are furnished with wings, are the only individuals that exercise the sexual functions. Several particulars, with regard to the economy of ants, were published by Mr Gould, in a book entitled "An account of English Ants," of which an abstract is given in the *Philosophical Transactions* for 1747, by the Rev. Dr Miles. The facts are there stated with tolerable correctness; but some errors have been committed by following too closely the analogy with bees. Geoffroy (*Histoire des Insectes qui se trouvent aux environs de Paris*), though a good naturalist on other topics, is a bad authority on the subject of ants. The most complete series of observations on the natural history of these insects, is that for which we are indebted to the celebrated Swedish entomologist De Geer (*Mémoires pour servir à l'histoire des Insectes*), an observer on whose fidelity the most implicit reliance may be placed.

In the *Encyclopédie Méthodique*, under the article *Fourmi*, Olivier has drawn up an able statement of all the material facts that had been established by preceding naturalists, without, however, adding any original observations of his own, excepting the description of five or six undescribed species. A full account of the habits of those ants, which for a long period infested the Island of Martinique, is contained in some of the earlier numbers of the *Journal de Physique*, (Vols. IX. and X.) The author of these memoirs, M. Barboteau, has given many curious details on this subject, and has cited a number of facts on various authorities; and the account might now be swelled by the reports of subsequent travellers in different parts of the world; but these statements are often made upon slender authority, and are too much tinctured with the marvellous to admit of much credit being attached to them. The narrative given to us by Bonnet, in the second volume of his *Observations sur les Insectes*, of the proceedings of a colony of ants, which had established itself in the head of a large thistle, and which he transported into his house, is highly interesting; but it elucidates only a few points of their economy, and leaves us to regret that so patient and indefatigable an observer had not bestowed more of his attention to the study of this tribe of insects. In the *Philosophical Transactions* for 1790, we find an interesting memoir on the Sugar Ant, a species which, for a period of ten years, committed dreadful ravages in the sugar plantations throughout the whole Island of Grenada. The most methodical account of this tribe of insects that has yet appeared, is that of Latreille, in his *Histoire Naturelle des Fourmis*, published at Paris in 1802; a work which alone would have secured the reputation of the author as an able and scientific naturalist. His merit is particularly conspicuous in the clearness and accuracy of his descriptions of each species, and the luminous method of arrangement which he has adopted in their classification. He gives an account of one hundred species, which he had himself observed, and of twenty-four which he has described from the reports of others; these he distributes into nine natural families, according to the situation and structure of the antennæ, and the form of the abdominal scales. But the work which contains the most copious collection of facts relative to the habits and economy of ants, is that of Mr P. Huber, of Geneva, entitled *Traité des moeurs des Fourmis Indigénes*, published in 1810. By means of an apparatus, which he contrived so as to admit of his obtaining a view, whenever he pleased, of the inmost recesses of their habitation, he was enabled to observe what was going on in the interior of the nest, and to investigate, with success, some of the most important and interesting features of their history. The results of his researches, as they are reported in his work, are highly curious and instructive, and open a wide field of speculation and inquiry to the philosophical entomologist. They have not only elucidated many obscure points with regard to one tribe of insects, but have disclosed some general views of the instincts and faculties of this order of the creation, which are totally new, and must tend, in a considerable degree, to exalt our conceptions of the inexhaustible powers and resources of nature.

Economy and Policy of Ants.

Having thus pointed out the principal sources of information in this department of entomology; we shall proceed to give an outline of the leading facts that have been ascertained relative to the economy and domestic policy of these remarkable insects.

Functions of the Neuters.

In common with many tribes of hymenopterous insects, ants present the remarkable peculiarity of a threefold distinction of sex among the individuals of the same species; a circumstance which is met with in no other order of the animal kingdom, and which appears, as far as observation has extended, to be totally excluded from the plan of the vegetable

Ant.

creation. Besides males and females, there exists an apparently intermediate order of *neuters*, which are also denominated labouring or working ants. The neuters, thus exempted from every sexual function, exercise, on the other hand, all the other offices necessary for the existence and welfare of the community to which they belong; it is they who collect supplies of food, who explore the country for this purpose, and seize upon every animal substance, whether living or dead, which they can lay hold of, and transport to their nest. It is they who construct every part of their dwelling-place, who attend to the hatching of the eggs, to the feeding of the larvæ, and to their removal, as occasion may require, to different situations favourable to their growth and developement; and who, both as aggressors and as defenders, fight all the battles of the commonwealth, and provide for the safety of their weaker and more passive companions. Thus all the laborious and perilous duties of the state are performed solely by this description of ants, who act the part of Helots in these singularly constituted republics of insects. We find, however, on closer examination, that, in all probability, this anomaly in point of sex is more apparent than real; and that, however different in external conformation to the productive females, they nevertheless originally and essentially belong to the same sex. There is every reason to believe that the developement of the sexual organs in the former is the consequence of some difference in the circumstances in which the larva is placed during its growth. That such is the case with bees, is now perfectly well established; and the analogy of bees with ants, in many points of physiology, must be admitted as a strong argument in corroboration of this theory. In all the essential features of internal structure, the supposed neuters agree with the female, and differ from the male of the same species. In all hymenopterous insects, which are armed with stings, a difference exists in the two sexes, as to the number of articulations composing the antennæ; those of the female consisting of fewer pieces than those of the male. The accurate observations of Mr Kirby *(Monographia Apum)*, have determined that in the bee the antennæ of the male have fifteen articulations, while those of the female and the neuter have only fourteen. In the ant, likewise, we find thirteen articulations in the male, and twelve only in the female; and likewise only twelve in the neuter. In the male ant the abdomen has seven rings, in the female and neuter only six. In the two latter classes the head is broader, and the mandibles very large and powerful, compared with those of the male, and are furnished with serrated edges, and a sharp and often hooked point. The external sexual organs of the female and of the neuter are so nearly similar in appearance, that Latreille declares he was unable to perceive the least difference between them. On the other hand, it is to be observed, that, in the neuter, the principal deviation from the model of the female consists in the absence of wings; a circumstance which, as it regards the organs of locomotion only, is one of subordinate importance in the economy; and their presence may, without difficulty, be conceived to be connected with a certain condition of the sexual organs, as are the horns of the deer, and the beard in the human species. But although of so little consequence in a physiological point of view, it is a circumstance materially affecting their external condition. It dooms them to severe toil and exertion in traversing the ground, and in climbing up the steep paths that may lie in their route; while their more luxurious and favoured associates are fluttering in the spacious realms of air in search of amusement, and wafted to the objects of their gratification on the light breezes of the summer.

**Sensitive Powers of Ants.**

Ants appear to be endowed with a greater share of muscular strength than almost any other insect of the same size. Of this we have sufficient proofs in the vivacity of their movements, the incessant toil which many undergo, the great loads which they are seen to carry, often exceeding ten or twelve times their own weight, and the agility which they exert in making their escape from danger. This high degree of irritability is conjoined, apparently, with a corresponding share of the power of sensation; a power which is manifested in their susceptibility to a variety of impressions capable of affecting the organs of sense. They have a quick perception of all changes of temperature, as well as of other conditions of the atmosphere; and are readily, and disagreeably, affected by moisture. In the perfection of the sense of sight they seem to be nearly on a level with other insects; and the males and females are provided with both the descriptions of eyes peculiar to this class, namely, the composite and the simple eyes. The labouring ants, indeed, who never fly, are frequently destitute of the latter kind: a circumstance which appears to confirm the suspicion that has often been entertained, that the simple eyes are chiefly instrumental in the vision of distant objects. Latreille describes two species of ants, in which he could not discover the least appearance whatsoever of eyes, although he employed a high magnifying power in examining them. One of these (the *Formica cæca*) is a foreign species, inhabiting the forests of Guiana, and of which the history is therefore little known. The other (the *Formica contracta*) is met with in the vicinity of Paris. It always conceals itself during the day, under stones, or in obscure recesses, where no light can penetrate; and emerges from its retreat only during the night. It is much less social in its habits than other ants, collecting in groupes only of about a dozen individuals, and appears to be far inferior in sagacity to the rest of the tribe.

Ants possess a considerable acuteness of smell, a sense which appears to be useful not only in directing them to their food, but also, as Bonnet first remarked, in enabling them to follow by the scent the tract of their companions. If the end of the finger be passed two or three times across the line of their march, so as to brush off the odorous particles with which the ants who had already passed that way may have impregnated the track, those who follow immediately stop on arriving at the place where the experiment has been made, and afterwards direct their course irregularly, till they have passed over the space touched by the finger, when they soon find the path, and proceed with the same confidence as before.

Bonnet repeated this experiment frequently, and always with the same result. Latreille has endeavoured to discover the seat of smell, which had long been suspected to reside in the antennæ. He, with this view, deprived several labouring ants of these organs, and replaced them near their nests. When thus mutilated, they wandered to and fro in all directions, as if they were delirious, and utterly unconscious of where they were going. Some of their companions were seen to notice their distress, and approaching them with apparent compassion, applied their tongues to the bleeding wounds of the sufferers, and anointed them with a liquor, which they caused to flow from their own mouths. This trait of sensibility was repeatedly witnessed by Latreille, while he was observing their actions with a magnifying lens.

It is indeed evident that, in all insects, the antennæ are organs of the greatest utility in conveying impressions from external objects. But in the ant, independently of their importance as organs of touch, they appear to be of still greater consequence to the welfare of the individual, and of the community to which it belongs, by being the chief instruments which enable them to communicate to one another intelligence in which they are mutually interested, and on which they are called upon immediately to act. Mr Huber, to whom we are indebted for a variety of curious observations on this subject, has given the name of *Language Antennal* to this species of intercourse. The situation of the antennæ, which are placed in front of the head, their great mobility, their peculiar mechanism, which presents a series of phalanges having great freedom of play, and endowed with exquisite sensibility, conspire to fit them admirably for the function which he assigns to them,—that of producing a variety of different impressions, when applied in different ways to the antennæ, or other parts of those ants, with which they come in contact. Thus the signal of danger, which consists in the ant which gives the alarm striking its head against the corselet of the other, is propagated from ant to ant with astonishing quickness, throughout the whole society. For a few minutes a general ferment prevails, as if they were deliberating what measures to pursue; but their resolution is soon formed, and they are ready to rush in a body against the enemy. Any small animal that is discovered to have insolently invaded their repose, is certain of falling a victim to their resentment; unless he can make a precipitate retreat, which he seldom effects without being covered with the bites of these furious insects. They are not, however, equally jealous of the intrusion of every kind of insect, for woodlice are often found in the interior of the nest, to whom, according to Latreille, they offer no molestation. Ants appear to be incapable of emitting sounds, so as to communicate with one another at a distance: and there is, indeed, no evidence that they possess the sense of hearing. The consideration of the sense of taste naturally comprehends that of their food, to which we shall therefore next proceed.

Their Food; and Depredations.

Very erroneous opinions were prevalent with regard to the food of ants, which have often been supposed to consume corn, and to do great injury to plants by devouring their roots or stems. The truth is, that they are chiefly carnivorous insects, preying indiscriminately on all the softer parts of animals, and especially the viscera of other insects. These, indeed, they will often attack when alive, and overpower by dint of numbers; either devouring their victim on the spot, or dragging it a prisoner into the interior of the nest. If, however, the game should be too bulky to be easily transported, they make a plentiful meal, and exert, like the bee, a power of disgorging a portion, and of imparting it to their companions at home: and it appears that they are even able to retain at pleasure the nutricious juices unchanged for a considerable time. The rapidity with which they consume, and in fact anatomize the carcasses of any small bird or quadruped that happens to fall in their way, is well known; and furnishes an easy method of obtaining natural skeletons of these animals, by placing their dead bodies in the vicinity of a populous ant hill. In hot climates, where they multiply to an amazing extent, their voracity and boldness increase with their numbers. Bosman, in his description of Guinea, states that, in one night, they will devour a sheep, leaving it a fine skeleton; while a fowl is for them only the amusement of an hour. In these situations, they will venture to attack even living animals of considerable size. Rats and mice often become their victims. The sugar ants of Grenada cleared every plantation which they visited of rats and other vermin, which they probably effected by attacking their young. Poultry, or other small stock, could not be raised without the greatest difficulty; and the eyes, nose, and other emunctories of the bodies of dying or dead animals, were instantly covered with them. They generally, indeed, begin their attacks on the most sensible parts, which have the finest cuticle: and accumulating in great numbers about the nostrils, destroy the animal by interrupting respiration. Negroes with sores had difficulty in keeping the ants from assailing them. Their power of destruction keeping pace with their increase of numbers, it is hardly possible to assign limits to either; and the united hosts of this diminutive insect have often become formidable to man himself. A story is related by Prévost, in his *Histoire Général des Voyages*, of an Italian missionary, resident in Congo, who was awaked by his negroes in great alarm at the house being invaded by an immense army of ants, which poured in like a torrent, and before he could rise, had already mountted upon his legs. They covered the floor and passages, forming a stratum of considerable depth. Nothing but fire was capable of arresting their progress. He states that cows have been known to be devoured in their stalls by these daring devastators. Smith, in his *Voyages to Guinea*, reports that at Cape Corse the castle was attacked by legions of ants, who were preceded by thirty or forty, apparently acting as guides. It was at day break when they made this incursion, entering first by a chapel, on the floor of which some negro servants were lying. Assailed by this new enemy, they fled with precipitation, and gave the alarm to their master, who, on awaking, could hardly recover from his astonishment at beholding the advancing multitude, which extended for a quarter of a mile before him. There was not much

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time for deliberation; and a happy expedient was adopted of putting a long train of gunpowder across the line of their march, and extending it to their flanks, which had already began to deploy, and, setting fire to the whole, millions were destroyed at one blow, which so intimidated the rest, that the whole army retreated in disorder, and did not renew the attack.

Descriptions of ant hills of immense size abound in books of travellers who have visited tropical regions. Mr Campbell (*Account of Travels in South Africa*, published in 1815) observed in the district of Albany, at the Cape, an ant hill, five feet high, and twelve in circumference. In the forests of Guiana, according to M. Malouet, they attain the height of from fifteen to twenty feet; and, when viewed from a distance on these widely extended savannahs, resemble the rude huts of savages: but they contain a race more ferocious than the savage or the tiger himself, and cannot be approached by men without the utmost danger of being devoured. When new settlers, who are clearing the country, meet with any of these in their progress, they must immediately desist from their task, and even abandon the neighbourhood, unless they can speedily destroy the enemy in the very heart of the citadel which protects him, and from which he is able to pour an overwhelming number of combatants. The only method of accomplishing this, is to dig a trench all round the ant hills, and, after having filled it with dry wood, and set fire to it on every side by lighting it quickly in different places, so as to cut off all retreat to the ants, to batter down the edifice with cannon. The ants, thus scattered, soon perish in the flames.

The chief, if not the only vegetable substance which is at all alluring to their appetite is *sugar*. They not only eat it in substance, but are fond of all fluids that contain it in any quantity,—such as the secretions which exude from many trees, and compose what has been termed the honey-dew; and the saccharine juice, which is excreted from the bodies of many of the insects belonging to the genus Aphis. This latter species of food they appear to relish above all others; it resembles honey in its qualities, and is sucked with avidity from the insect which yields it, and which appears in no respect to suffer from the operation. Boissier de Sauvages was the first who noticed this singular fact; and Mr P. Huber has ascertained a number of curious circumstances attending it. He conceives that the liquor is given out voluntarily by the aphis, at the solicitation of the ant, who, for this purpose, strikes it gently and repeatedly with its antennæ, using the same motions as it does when caressing its young; and remarks that the aphis retains this liquor for a longer time, where the ants are not at hand to receive it. A single aphis may often be seen surrounded by three or four ants, who are feeding on the honey, and deriving from it a plentiful meal. It does not appear that the aphis uses any exertion to avoid the ants, who are thus dependent on its bounty; for those provided with wings, which would easily enable them to escape, are quite as passive under these circumstances as the rest.

The cultivation of the sugar-cane in the West Indian islands, has often been severely checked by the ravages of ants; but the injury they occasion arises altogether from their undermining the roots, in order to establish their nests where they can be protected from heavy rains, and secured against agitation from violent winds; advantages which the sugar-cane affords them in a very great degree. No part of the plant constitutes their food: and the same is true of those trees among the roots of which they burrow, and of which they speedily occasion the destruction, by preventing the access of moisture.

Ripe fruits are often attacked by ants, probably on account of the sugar they contain; and, for the same reason, the buds of trees are infested with these insects, and often injured by their depredations. There is no evidence, that they, at any time, feed upon corn, or other vegetable seed. This point has been well established by Mr Gould: and Bonnet, who kept a colony of ants prisoners in his study, observed, that, however long they had been kept without food, still they never touched the corn that he put before them. Honey and sweetmeats have strong attractions for ants, who, if they once discover their way to a magazine of these dainties, will immediately communicate the tidings to the rest of the society, and, leading them to the spot, a regular path will soon be established, which will continue to be crowded with a train of depredators, so long as any thing remains to be pilfered. It is, however, certain, notwithstanding the assertion of Bomare, who compares them to the miser, whose chief pleasure consists in contemplating the riches he has amassed in his coffers, that ants are not in the habit of hoarding provisions for future consumption. They grow torpid when the cold exceeds 27° of Fahrenheit, and in that state require no food, and the aphis affords them sufficient nourishment at other periods of the winter.

Their Nests.

In building their nests, each species of ant follows its own peculiar mode of construction, and employs different materials for this purpose. Many form them of clay, and particularly the smaller species; one set building up a regular series of apartments in successive stories, often forty in number, with materials which are furnished to them by another set of workers, who are excavating the ground below. The ceilings are supported throughout by small pillars in some parts, and by vertical walls in others; while broad arches are in other places raised, in order to protect larger spaces, and to admit of lengthened passages of communication throughout a long extent of apartments. These ants can proceed in the building only at such times as the earth has been softened by rain or dew, and the atmosphere is at the same time sufficiently moist to allow of the materials cohering firmly before they dry. Such are probably the ants, which Pliny mentions as working by moonlight. On one occasion, when the ants, under the inspection of Mr Huber, had discontinued their labours on account of too great dryness in the atmosphere, he succeeded in getting them to renew their operations by sprinkling water upon them with a wet brush, in imitation of a natural shower. They care-

fully close the doors of their habitations every night, in order to prevent the intrusion of other insects; and a few remain on the outside during the night, as centinels, to give the alarm in case of danger. Some species of ants collect fragments of leaves, of bark, or of straw, with which they construct more permanent and artificially constructed nests than the former. Others employ nothing but the fine powder which they collect from decayed wood. Some establish themselves for greater security under a large stone, or in the crevices of decayed buildings. Several tribes, on the other hand, penetrate into the solid substance of wood, which they scoop out into numerous cells, leaving only intermediate partitions of extreme tenuity, just of the strength sufficient to enable the whole fabric to support itself; while it crumbles into powder when pressed between the fingers.

Fœcundation, and Growth of their Young.

We shall now take a brief review of the principal circumstances relating to the fœcundation of the ant, and the evolution and growth of the young. The former is effected very generally during the flight of the females, in which they are accompanied by the males; both appearing to be provided with wings chiefly for this object. A certain number of the females that are impregnated, are also, by the assistance of their wings, enabled to reach distant situations, where they become respectively the founders of new colonies. The males, on the other hand, having fulfilled the office for which nature had destined them, are left to perish on the spot where they descend, being removed from those who formerly administered to them food, and being destitute of the means of procuring subsistence for themselves. Immense swarms of ants are occasionally met with; and some have been recorded of such prodigious density and magnitude as to darken the air like a thick cloud, and to cover the ground to a considerable extent where they settled. Mr Gleditsh describes, in the *History of the Berlin Academy*, for 1749, shoals of a small black ant, which appeared in Germany, and formed high columns in the air, rising to a vast height, and agitated with a curious intestine motion, somewhat resembling the Aurora Borealis. A similar flight of ants is spoken of by Mr Acolutte, a clergyman of Breslaw, which resembled columns of smoke, and which fell on the churches and the tops of the houses, where the ants could be gathered by handfuls. In the German *Ephemerides*, Dr Charles Rayger gives an account of a large swarm, which passed over the town of Posen, and was directing its course towards the Danube. The whole town was strewed with ants, so that it was impossible to walk without trampling on thirty or forty at every step. And more recently, Mr Dorthes, in the *Journal de Physique*, for 1790, relates the appearance of a similar phenomenon at Montpellier. The shoals moved about in different directions, having a singular intestine motion in each column, and also a general motion of rotation. About sunset they all fell to the ground; and, on examining the ants, they were found to belong to the *Formica nigra* of Linnæus.

The swarming of ants does not appear to be at all analogous to that of bees: its object seems to be confined to the propagation of the species, and is not the result of any co-operation of numbers, who associate together in search of a new habitation, in which an already populous assemblage may establish themselves. It would appear that the infant colonies consist of very small numbers, and are perhaps wholly the offspring of a common parent, who has migrated alone, or with but a few companions. The greater number of impregnated females alighting in the neighbourhood of the nest, are laid hold of by the labouring ants, who immediately deprive them of their wings, and drag them to the nest, where they keep them prisoners, till they are ready to deposit their eggs. Each female is, at this period, attended by a numerous retinue of labourers, who treat her with the greatest deference, and are solicitous to anticipate all her wants. Contrary to what happens among bees, many females inhabit the same nest, and live together in the utmost harmony. The eggs, when first deposited, are very small, but become considerably larger before the larva is excluded; being apparently nourished by absorption; for the ants, to whose care they are confided, are perpetually licking them with their tongues;—a fact, which, however curious, is by no means a solitary one in the history of insects. The larva comes forth at the end of a fortnight, and appears in the form of a transparent maggot, with a head and wings, but without any external organs of motion. They are in this state fed by their nurses, with a fluid disgorged from their stomachs; and in the course of their transformation to the state of nympha, and of perfect insect, are still dependent upon their assistance. These affectionate guardians help them to extricate themselves from the web of the cocoon, to unfold the duplicatures of their wings, and supply them with food, till they are capable of procuring it for themselves. The young ant is an exceedingly tender and delicate animal, easily destroyed by any considerable variation of temperature, or by excessive humidity; and great care and attention appear to be required to bring it to maturity: it appears to be the constant business of the ants which remain at home to convey them to different parts of the nest, where the temperature is suited to them; and, whenever danger threatens, they show the utmost solicitude to remove them to situations of security.

Their Sagacity.

Very different degrees of sagacity belong to different tribes of ants. Many traits in the history of the larger kinds, as related by Huber, are of so singular a character, as to be scarcely credible, if we had received them from a less reputable authority; and, if we were not already prepared to admit them, from our knowledge of many equally curious circumstances in the economy of bees, which have been established by the concurrent testimony of the most scrupulous observers. Some tribes of ants, according to this naturalist, who are peculiarly fond of the honey which exudes from the aphis, convey many of these insects into their own nests, lodging them near the vegetables on which they feed, but keeping them prisoners within their habitations, and assigning to them distinct apartments in the subterranean recesses of their dwellings. As if conscious of the future advantages they may derive from these insects, they

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collect their eggs, and superintend their hatching with the same care which they bestow on the eggs of their own species. The aphis lives in perfect harmony with its keepers, who, so far from molesting it, defends it with courage against ants belonging to other nests, who frequently attempt to get possession of them. Occasionally, they are lodged by the ants in fortified buildings, which they construct at a distance from the nest, in situations where they are most secure from invasion. The aphis is not the only genus of insect which furnishes this kind of provision to the ant; the kermes and gall-insect are employed occasionally for the same purpose; and are found domesticated in the nests of ants, at the same time that they contain several species of aphis, and from all of which they collect nutriment.

Their Wars.

This picture of domestic harmony is strongly contrasted with the scenes of ferocious contention, which are occasionally exhibited between the inhabitants of neighbouring nests; nature appearing to have instilled, together with the love of social order, the same passions of rivalry, of ambition, and of revenge, of which we deplore the operation among beings of a higher order. War, the scourge of the human species, exerts its desolating power among the tribes of gregarious insects, and tends to check their otherwise excessive increase of number. The battles which take place between rival colonies of ants, are often on a scale of prodigious magnitude: millions of combatants engage on either side, with a fury and pertinacity that is truly astonishing. Their weapons of offence are the jaws, which are capable of inflicting a deep bite, and of instilling into the wound a highly acrid liquor; and also, in many species, a sting resembling in situation and structure that of the bee, and likewise containing a venomous juice. This liquor is well known to possess acid properties, and, though long supposed by chemists to contain a peculiar acid, which was denominated the Formic, has been satisfactorily shown by Fourcroy and Vauquelin, to consist of the acetic and malic acids, combined with a portion of acid animal matter, to which it owes its peculiar taste and smell. It is extremely volatile and pungent, and is capable of being thrown out by the ant, when irritated, in considerable quantities. Roux, in the *Journal de Médecine* for 1762, reports a number of experiments which were made by exposing animals to its influence. Frogs were killed by the vapour from an ant's nest in less than five minutes: and persons breathing it, when of a certain intensity, were nearly suffocated, or were seized with fever, followed by an extensive cutaneous eruption, which terminated in desquamation of the cuticle.

Some of the most daring and courageous species, such as that which M. Huber calls the *Amazon-ant*, make it the business of their lives to attack the nests of the weaker species, and succeed, after a desperate conflict, in plundering them of their eggs and larvæ, which they convey to their own nests. These are hatched and reared by ants of the same species as themselves, who may be considered as auxiliaries to the Amazons, and who had themselves, at some former period, been kidnapped from their parent nest by the Amazons. Thus, a society is formed among different species of insects, to which no parallel exists but in the human race. The Amazons live without labour: they are attended, fed, and cherished by the ants which they have procured by this kind or slave trade, and who take as much care of their offspring, as they do of those of their own species. Perfect order is preserved, and the natural instinct of hostility, which in another condition of the society exists between the two tribes, seems in the auxiliaries completely extinguished, by their being educated with the race of their original oppressors.

Ants have numerous enemies among quadrupeds and birds; and some, as the ant-eater, dasypus, and manis, or pangolin, together with the tribe of woodpeckers, devour a very large proportion. The *Formica leonis*, or myrmelion, feeds almost wholly on these insects. The bees at the Cape, according to Mr Campbell, frequently drive out the ants from their nests, of which they take possession themselves. Ants are also infested by lice, which, as may well be imagined, are so minute as to be invisible without the assistance of a very high magnifying power. They are stated by Redi, who discovered them, to resemble in shape those of the fowl and the dove.

Mode of destroying Ants.

The most effectual mode of destroying ants is to pour boiling water into their nests, which destroys at once both the perfect insects, and their eggs and larvæ; so that those who, being from home, had escaped the general catastrophe, finding it impossible to repair the loss, abandon the spot, and disperse. The addition of urine, or of soot, or still better of tobacco, which may be infused in the water, will render it much more efficacious. A decoction of walnut-leaves, or lime-water, will also generally answer. The night is the best time for applying these remedies, as the ants are then all collected in the nest. Arsenic is exceedingly destructive to ants, and affords another ready mode of getting rid of those that intrude into cupboards or pantries; it may, for this purpose, be mixed with sugar, or kneaded with any kind of provision, and placed in the paths they are observed to frequent. Corrosive sublimate is also highly poisonous to them, and myriads of the sugar-ants at Grenada were destroyed by means of it; and it is stated to have had the effect of rendering the ants so outrageous that they destroyed each other, as could be seen by a magnifying-glass, and even, though less distinctly, by the naked eye. It appears also that this effect was produced even when they only came in contact with the poison. The whole island, however, was so overrun with these ants, that the numbers that could be destroyed by these means bore no sensible proportion to the whole; and recourse was had to fire as more applicable to destruction on a larger scale. It was observed that when wood, burnt to the state of charcoal, without flame, and immediately taken from the fire, was laid in their way, they crowded to it in such amazing numbers as soon to extinguish it, though thousands perished by so doing. Holes were therefore dug at proper distances in a cane-piece, and fire made in each of them. Prodigious quantities perished in this way; for those fires, when extinguished, appeared in the shape of mole-hills, from the numbers of dead that were heaped upon them. But as none of the females, or young brood, were destroyed by this ex-

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pedient, the ants soon reappeared in as great numbers as before; and the island would probably have continued subject to this scourge, had it not been for the occurrence of the great hurricane of 1780, which at once cleared all the islands of this dreadful pest, by which the sugar-cane plantations had been threatened with total ruin. (w.)

Situation and Boundaries.

ANTRIM, a maritime County of Ireland, in the province of Ulster, situate in the northern extremity of the Island. It presents a considerable line of coast to the Northern Ocean, and to the Irish Channel. By the former it is bounded to the north, and by the latter to the east. Carrickfergus Bay, and the river Lagan, on the south-east, divide it from the County of Down as far to the south as Spencer's Bridge. To the south-west it has the same County, which, running to a point, meets Lough Neagh at Shanport. The winding shores of Lough Neagh and Lough Beg form its boundaries on the west, as far as the point where it meets the river Bann; whence this river, taking a northern course, inclining to the west, separates Antrim from Londonderry.

Extent and Divisions.

This County lies between 54° 26′, and 55° 12′ 16″ north latitude. Its greatest length from Bangorehead north, to Spencer's Bridge south, is about 56 English miles; and its greatest breadth, from the Gobbins east, to Island Reagh Toome west, about 30 miles. Its area comprises 972 square miles, or 622,059 English acres. It contains eight Baronies,—Dunbra, Carey, Killconeray, Glenarm, Toome, Antrim, Belfast, Massarene. All of these, except Killconeray and Carey, are subdivided into half Baronies, called upper and lower. There are also smaller divisions into Constablewicks and Town-lands. As nearly all the names of the Townlands are Irish, and expressive of the qualities of the land, or of some other local circumstance, it is probable that this subdivision is of very ancient date. Ploughlands were instituted in the reign of Philip and Mary, but this division is now quite laid aside. The number of parishes is seventy-seven. The chief towns in this County are Antrim, Belfast, Carrickfergus, Lisburn, Ballimena, and Ballimoney. It returns five members to Parliament, *viz.* two for the Shire, and one for each of the three principal towns, Belfast, Carrickfergus, and Lisburn. The assizes, elections, &c. are held at Carrickfergus, and the quarter-sessions at Antrim. The Bishopric of Connor comprehends the whole County, except the parish of Aghalee or Soldierstown, in the Barony of Massarene, which is in the Diocese of Dromore, and the parish or grange of Ballicullen, which belongs to the Diocese of Derry.

Face of the Country.

The interior of the County, on the eastern side, is mountainous, destitute of plantations, and abounding in bogs. This character also, in a great degree, applies to the northern side. The Baronies of Belfast and Massarene are the most level and fruitful. That remarkable range of basaltic pillars, called the Giant's Causeway, on the northern coast of Antrim, is described in the original work, under the head GIANT'S CAUSEWAY.

Mountains.

The principal mountains are Devis, near Belfast; Slenish, towards the middle; and Knocklayd, in the northern part of the County.

Minerals.

Besides basalt, limestone, gypsum, coals, fossil-wood, or woodcoal, sandstone, &c. are found. The fossil-wood, or woodcoal, in most places, is covered with columns of basalt, and is curious, as explanatory of the origin of coal. Notwithstanding the compressed state in which it is found, the bark and knots are quite distinct, and the rings, denoting the annual growth of the wood, may be counted. In some instances, the roots of the trees may be traced. Of the only two coal-mines which are wrought in the province of Ulster, there is one in Antrim, at Ballycastle. The coals are bituminous, and of a bad quality; a great part of them are exported.

Rivers.

The rivers of this County are very numerous, but in general small. The most considerable are the lower Bann, which discharges the waters of Lough Neagh into the sea; and the Lagan, which falls into the ocean near Belfast. Lough Neagh, belonging more properly to the County of Armagh, will be described under that article. It may be proper, however, to notice in this place, that of the two Islands in this expanse of water, Ram Island, from its contiguity to Antrim, is considered as belonging to that County.

Rathlin Island.

Rathlin Island lies off the northern coast of this County, opposite to Ballycastle. It is about five miles in length, and about three quarters of a mile in breadth. The number of its inhabitants is about 12,000. It is celebrated as having afforded a place of refuge to Robert Bruce.

Climate.

No regular and accurate accounts of the climate of Antrim have been kept, except at Belfast; and from these it appears, that less rain falls here than is generally supposed; the annual fall of rain, on an average of six complete years, being only 24.700 inches. The prevalent wind is the south-west. The greatest height of the barometer between the years 1796 and 1809, was 31 inches; the lowest 28 inches. The greatest height of the thermometer, during that period, was 78°.80; the lowest 25. The mean temperature of the northern coast of Antrim, near the town of Ballycastle, in latitude 55.12, as observed in the year 1788, by means of copious springs flowing from limestone soil, was 48°.

State of landed Property.

The estates in Antrim are in general freehold, being either immediate grants from the Crown, or held under those grants. The exceptions are the properties under the See of Connor. Some of the estates are very large. The Marquis of Hertford, and the Antrim family, possess the fee of the major part of the County. The former has 64,000 *green acres*, that is, land capable of tillage, independently of bog and mountain. Most of the Antrim estate is let on perpetuity, in farms worth L. 2000 or L. 3000 per annum. The other great proprietors are the Marquis of Donegal, Lord Templeton, and Lord O'Neil. The estate of Lord Templeton, however, is only leasehold under the Marquis of Donegal, who lets his land for 61 years and a life, but renews at the end of a few years for a fine. By a return to the House of Commons, 7th of February 1816, the number of persons who have registered freeholds in this county, between the 20th February 1807 and the 21st of February 1815, of the value of forty shillings, was 8074; of the value of L. 20, 152; and of the value of L. 50, 227.

Agriculture.

The farms in Antrim are in general very small;

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the average of the rent of the *green land* is estimated at between 30s. and 25s. the Irish acre. The principal feature in the tillage system of a great part of Antrim, is the potatoe fallow. The small size of the farms, and, in some places, the rockiness of the soil, precludes the use of the ordinary means of culture, and therefore a part of the land is dug with the spade. The quantity of potatoe-land is regulated by the quantity of manure that can be collected. After potatoes, flax is sown, and the quantity of flax ground is regulated by the ability to purchase the seed. A crop of oats finishes the regular rotation. When the ground is exhausted, it is turned to rest, that is, it is suffered to lie till it is covered with natural grass. Such is the most general plan of husbandry pursued in Antrim. In those parts where the farms are too large for the spade culture, the land is ploughed by three or four neighbours uniting their strength; one supplying the plough, and the others bringing a horse, bullock, or even a milch cow. Wheat is a plant of very modern introduction in Antrim, and very little of it is sown. The quantity of seed sown to the Irish acre, varies from 224 to 171 lbs. avoirdupois; and the produce from 2272 to 2135. Bear or bigg is grown only in the colder and higher parts of the County; the seed used is 203 lbs.; the produce 3500. The quantity of barley used as seed varies from 203 to 209; and the produce from 2982 to 2646. Of oats, the seed varies from 333 to 291, and the produce from 3636 to 3227. Of potatoes, the seed varies from 2392 to 1383, and the produce from 22,248 to 15,183.

Flax.

The most important crop in Antrim is flax. The total number of acres supposed to be sown with flax in the year 1809, was 11,000; and the total number of bushels of flax-seed, supposed to have been saved out of the crops, was 3100. The annual average of flax-seed imported into Belfast is 5000 hogsheads, of about seven bushels each. The quantity of seed generally used for an acre is 30 gallons; the produce of seed averages 785 gallons: the average produce of flax is 30 stone per acre.

Live Stock.

The cattle in Antrim consist chiefly of milch cows belonging to small occupiers, of a small stunted breed. Sheep are very little attended to; and the few that are kept are of a very inferior kind. Goats are numerous in the mountainous parts of the County. Pigs also are kept in great numbers. During the salting season of 1811, not fewer than 70,000 pigs, weighing at least 200 lb. each, were brought to Belfast for exportation.

Trees.

This County by no means abounds with wood: nor are fruit-trees cultivated in great abundance, or with very much success. Of the apple, however, several new, and valuable varieties have lately been introduced, and advantageously cultivated.

Manufactures.

Antrim has long been distinguished for its linen manufacture; but latterly, the manufacture of cotton has, in some measure, supplanted it, especially in the vicinity of Belfast. In the year 1800, about 23 years after the introduction of the cotton manufacture, 13,500 people were *directly* employed in it; and including all manner of persons occupied in it in various ways, the number was 27,000, within a circuit of 10 miles; comprehending, however, the towns of Belfast, and Lisburn. The cotton yarn is chiefly brought from Scotland.

Linen Manufacture.

The linen manufacture, notwithstanding, is still the staple manufacture of Antrim. It is a peculiarity of this manufacture, as it is established in Ireland, that it does not remove the peasant from the comforts and healthiness of rural life. In Antrim, the weaver and the labourer of the soil are united in the same person. Many weavers have small farms, and only employ themselves in weaving during the intervals of their farming occupations; and almost all who pursue this trade, possess gardens, and ground for potatoes. Many of the houses have three looms, which cost from four to five guineas each: Children are hired to attend a loom at from 13s. to 17s. the half year, with diet, washing, and lodging: they bring a weaver eight guineas per annum. A good weaver will gain 10s. per web, and if he worked every day, he could weave a web in a week. A loom will employ four spinners, who are all females, and will spin five hanks in a week, the price of which is 2s. 8½d.

Food of the Peasantry.

The consumption of food per week, by a manufacturing family, consisting of six persons, in this County, is 3½ bushels of potatoes; 14 herrings; 9 quarts of butter milk; and one pound of salt: the cost of which may be estimated at five shillings. The expence of a family, consisting of the same number of persons, the head of which works at agricultural labours, will be 7s. 6d. per week, as he occasionally uses meat, milk, and pork.

Salmon-Fishing.

There is a considerable salmon-fishing on the coast of Antrim, at a place called Carrick-a-rede. This place is separated from the mainland by a chasm 60 feet in width, over which, every year, at the commencement of the fishery, a bridge formed of two strong cables, and a number of boards, is thrown.

Antiquities.

The antiquities of this County consist of cairns, cromlechs, mounts, forts, ecclesiastical and military remains, round towers, &c. There are three round towers, viz. one near the town of Antrim; one at Ardmoy; and one in Ram Island, in Lough Neagh. A few years ago, a double patera of gold, weighing 19 ounces, 10 dwts. was found in this County.

Population.

The number of houses in the County of Antrim, in the year 1777, was 22,184; of which 20,519 paid for one hearth; 3667 for two or more; 1066 were newly inhabited; and 3002 belonged to paupers. In the year 1788 the number of houses was 28,254, and the population was estimated at 160,000. At this rate there were about 13 acres to a house, and about 48 persons on the square mile. In the year 1791, the number of houses was 30,314, of which 22,353 paid for one hearth, and 3746 were inhabited by paupers. The number of men returned, in the year 1810, between the ages of 16 and 45, fit to serve in the militia, was 24,425. Mr Dubourdieu, in his *Statistical Survey of Antrim*, estimates the present population at 240,000.

Antrim is supposed to contain a greater proportion of Protestants than any other County in Ireland; and of the Protestants a very great majority is Presbyterian; being connected with the General Synod of Ulster, or with the Burghers and Antiburghers of the Church of Scotland. This arises from the Scotch

extraction of the greater part of the inhabitants of this County. The Catholics principally occupy the mountainous districts. No person of this persuasion possesses landed property.—See Beaufort's *Memoir of a Map of Ireland;* Wakefield's *Account of Ireland, Statistical and Political;* Newenham *on the Population, &c. of Ireland;* and *Statistical Survey of the County of Antrim,* drawn up by the direction of the Dublin Society, by the Reverend John Dubourdieu. (c.)

ANVIL, in Smithery, and other manufactures of the malleable metals, is an instrument on which substances are laid for the purpose of being hammered.

For some purposes, anvils are made of cast-iron; but, when the face of the anvil is required to possess great hardness, or a bright surface, it is made of wrought-iron, and faced with steel. The core or body of wrought-iron anvils is prepared at the forge, where malleable iron is first formed into bars, or into masses for any particular purpose. The body of the anvil is formed by welding a number of smaller masses together under the forge-hammer. These are rude blocks of different sizes, according to the size of the anvil. Smaller masses are also furnished in this way, which the anvil-maker occasionally welds to the large blocks, for giving to the anvil any particular form.

The fire-place or hearth of the anvil-maker's forge is similar to the common smith's forge. His bellows are not double, like the latter. His fuel is cork, which produces a great heat, without much flame. Adjacent to the hearth is a crane, which, turning upon a pivot, brings the heated masses of iron from the fire to the anvil. The latter is a large mass of cast metal, about eighteen inches square on the face, and about a foot from the ground. When the core of the anvil to be formed is heated, the first thing is to make three square holes, one in the bottom, and one at each end of the anvil. These holes are about 1¼ inch long, 1 inch broad, and about 2 inches deep. They are for the purpose of receiving a bar of iron, which is connected with the crane by which the anvil is held in the fire, and by which it is turned and guided while forming with the hammers.

The common smith's anvil is generally made of seven pieces, namely, the core or body; the four corners, for the purpose of enlarging its base; the projecting end, which contains a square hole, for the reception of a set, or chisel, to cut off pieces of iron; and the seventh piece is the beak, or conical end, used for turning pieces of iron into a circular form, welding hoops, &c. These pieces are each separately welded to the core, and hammered so as to form a regular surface with the whole. When large pieces are required to be welded to the core, one fire is not sufficient to heat both at the same time. In this case two hearths are employed. The core and the piece are both raised to a welding heat. The piece being put into its place, is hammered by a quick succession of blows, till it adheres. The whole is again heated and hammered till the due form is obtained. The hammering is performed by a number of men at the same time, each using a large swing-hammer. The blows follow each other in regular succession; great experience and care being required to prevent the hammers from coming in contact with each other.



When the anvil has received its due form, it now requires to be faced with steel. This is performed by first preparing the steel face to the size of the anvil. The anvil is then heated to a strong welding heat in one fire, while the steel facing is heated in another, but not so hot as the iron. The anvil is now brought out, and placed in a proper position, and the facing is brought to it. The surfaces, which are to be brought together, are brushed, and the facing is then laid on, and hammered as rapidly as possible, till it is closely united. The whole is finished by repeated heating and hammering.

The next process is that of hardening the anvil. This consists in heating the face, in particular, to a full red heat, and quenching it in cold water. When a stream of water can be employed it is better. Where this cannot be had, the mass of water should be great, and the anvil moved about as quick as possible. The facing should be laid on as thin as it can be firmly welded. When it is too thick it is apt to crack in the hardening.

After hardening, the face is ground till it is perfectly even, and the edges made sharp, or round, as may be required. When the anvil is required for planishing metals, it is polished with emery, and afterwards with crocus.

The smith's anvil is generally placed loose upon a wooden block, the root-end of an oak tree being preferred. The anvils used in cutlery, and for files, are fastened into a large block of stone, which is doubtless better than having the anvil loose upon a small block. The more firmly the anvil is connected with the earth, and the substance it stands upon, the greater will be the effect of the blow of the hammer. (T.)

ANVILLE (JEAN BAPTISTE BOURGUIGNON D'), a French Geographer of the highest eminence, and perhaps the most celebrated in modern times. He was born at Paris, on the 11th July 1697. His passion for geographical research displayed itself from his earliest years. At the age of 12, while reading the Latin authors at College, he amused himself with drawing maps of the countries which they described. While he was thus busily employing himself one day in the class, his master observed, and was about to punish him; but, upon casting his eye upon the performance, he immediately judged him to be rather deserving of encouragement. D'Anville from this time devoted himself entirely to geography, particularly that of the ancient world; and, at the age of 22, he began to delineate maps, which attracted the attention of the most eminent Geographers.

There are two modes by which problems in geography may be solved; one mathematically, by astronomical observation, or geometrical measurement; the other historically, by the distances of places inferred from the narrative of historians and travellers. The former is certainly the most satisfactory, and would supersede every other, could it be extended over the whole surface of the Globe. But, notwithstanding the splendid progress made since the era of D'Anville, it is still far from such a degree of per-

fection. In all countries, the bulk of the positions must be filled up, and, in some, the whole must be constructed, from mere historical materials. Perhaps there is no department of science, which requires greater extent of knowledge, and accuracy of judgment. The variety of sources, out of which the materials must be drawn, is almost infinite; and their application is equally nice and difficult. It must be regulated by a complete acquaintance with all the modes of measurement used by all nations; by a careful notice of those errors and contradictions which naturally arise from a partial and limited observation; and by the marking of certain delicate processes in the human mind, by which space and distance are sometimes diminished, and more frequently exaggerated. In the skilful Geographer, sound natural judgment, enlightened by experience, creates, as it were, a new sense, which enables him to see consistency amid a labyrinth of contradictions, and to elicit truth from a multitude of statements that are all erroneous. This art may be said to have originated with D'Anville, and to have been brought by him to its highest perfection.

The course of study on which D'Anville entered was truly immense. Works professedly geographical formed the least part of it; those of all the ancient and modern historians, travellers, narrators of every description, were assiduously examined. He studied, but only for the sake of the occasional geographical lights which they afforded, the philosophers, orators, and poets; for it was remarked, that, in perusing these masterpieces of human genius, he was totally indifferent to every thing which did not tend to fix a geographical position. The object of this immense labour was to effect a complete reform in the science of geography; to banish the system of copying blindly from preceding maps, and never to fix a single position without a careful examination of all the authorities upon which it rested. By this process, he detected many and great errors in the works of his most celebrated predecessors; while his own accuracy was soon attested on all sides, by the travellers and mariners, who had taken his works as their guide. His principles led him also to another innovation, which was, that of omitting every name, for which there existed no sufficient authority. The public was at first amazed at seeing vast spaces, which had before been covered with Countries and Cities, suddenly reduced to a perfect blank; but they soon recognised, that this was the only accurate course, and that the defect lay in the science, not in the geographer.

D'Anville was at first employed in the humbler task of illustrating by maps the works of different travellers, such as Marchais, Charlevoix, Labat, and Duhalde. The question respecting the figure of the Earth coming to be much agitated, he published in 1735, and 1736, two treatises, with a view to illustrate it. But this attempt to solve a geometrical problem by historical materials, was eminently unsuccessful. Maupertuis having gone to measure a degree within the polar circle, the result was found directly opposite to our Geographer's prediction. This, however, was considered by the intelligent public, rather as fixing limits to his mode of investigation, than as implying any want of diligence and ability in its employment.

Any loss of reputation which this failure might occasion, was completely retrieved by his map of Italy, published in 1743. It was marked by a species of investigation, often employed by D'Anville with peculiar success. This consisted in the application of ancient materials to correct the existing geography. By the diligent study of the Latin authors, he was enabled to trace numerous errors which had crept into the delineation of this interesting country. A trigonometrical survey which Pope Benedict XIV. almost immediately after caused to be made in the Ecclesiastical States, confirmed, in a surprising degree, all these alterations. On this occasion, he first set the example, which cannot be too much applauded, of accompanying the map with a memoir, exhibiting a view of the data on which it had been constructed.

He now applied himself to ancient geography, always his favourite department, and the aspect of which, under his hands, was soon completely changed. He illustrated successively, by maps, all the countries known to the ancients, among which Egypt attracted his peculiar attention. To render these labours more extensively useful, he published in 1768, an *Abridgment of Ancient Geography.* His attention was finally turned to the middle ages, which were illustrated by his *States formed in Europe after the fall of the Western empire;* and by some other works equally learned. Entirely devoted to geographical inquiries, the appearance of his successive publications formed the only events by which his life was diversified. From causes which are not explained, he was late of being admitted into the Literary Societies. In 1754, at the age of sixty, he became a member of the Academy of Inscriptions and Belles Lettres, whose Transactions he enriched with many papers. In 1775, he received the only place in the Academy of Sciences which is allotted to geography; and in the same year he was appointed, without solicitation, first Geographer to the King. But these honours came too late to illustrate a life, which was now drawing to its utmost verge. His last employment consisted in arranging his collection of maps, plans, and geographical materials. It was the most extensive in Europe, and had been purchased by the King, who, however, left him the use of it during his life. This task performed, he sunk into a total imbecility, both of mind and body, which continued for two years, and ended only with his death in January 1782, when he had reached the great age of 85.

D'Anville, with the qualities which form the great Geographer, united all the essentials of an honourable and worthy character. The advancement of the science to which he had devoted himself, formed almost the sole passion of his life; and mingling little with society, he contracted peculiarities, which solitary study is but too apt to engender. He talked with little interest on any subject except geography. This topic necessarily led to that of his own discoveries, on which he was never weary of expatiating. He boasted without any reserve of the services which he had rendered to that science, using, not unfrequently, the expression of Augustus, "I found it of brick, and left it of gold." He, however, did full justice to the

D'Anville. merit of those who excelled in other branches of knowledge; and to such as furnished him with materials for his researches, his gratitude was unbounded.

We shall subjoin a list of the numerous memoirs and dissertations composed by D'Anville, of which some were published separately, and others in the Transactions of the Academies. The following were published separately:

1. Mémoire pour faire la carte du diocèse de Lizieux.
2. Mémoire pour la révision de cette carte.
3. Mémoire instructif pour dresser des cartes particulières, avec une carte *in-folio*.
4. Observations sur la carte du Paraguay, avec une carte d'une demi-feuille.
5. Proposition d'une mesure de la terre, avec une carte d'une demi-feuille.
6. Mesure conjecturale de la terre sur l'équateur, avec une carte d'une demi-feuille.
7. Réponse de M. d'Anville au mémoire contre cette mesure.
8. Lettre au P. Castel, sur le Kamtchatka, avec une carte d'un quart de feuille.
9. Article de la géographie, tiré de l'Histoire ancienne de Rollin.
10. Nomenclature alphabétique de l'Italie, tirée de l'Histoire Romaine de Rollin.
11. E'claircissemens sur l'ancienne Gaule, avec deux cartes de deux demi-feuilles.
12. Lettre à M. de la Roque, sur un lieu nommé anciennement *Chora*.
13. Mémoire pour dresser des cartes d'un canton renfermant dix ou douze paroisses.
14. Analyse de l'Italie, avec trois cartes de 4 feuilles *in-folio*.
15. Mémoire pour dresser une carte de la généralité de Soissons.
16. Dissertations sur l'ancienne Jérusalem, avec une carte de demi-feuille.
17. Lettres sur la carte de l'Amérique méridionale, avec une carte de 3 feuilles *in-folio*.
18. Eclaircissemens sur la carte de l'Inde, avec deux cartes de 5 feuilles *in-folio*.
19. Mémoire sur la carte du Canada, etc., avec une carte de 4 feuilles *in-folio*.
20. L'article Vents Etésiens, tiré de l' Encyclopédie.
21. Analyse de la carte des côtes de la Grèce, avec une carte *in-folio*.
22. Notice de l'ancienne Gaule, avec une carte *in-folio*.
23. Mémoires sur l'Egypte ancienne et moderne, avec 5 cartes, dont 2 *in-folio*.
24. Géographie ancienne abrégée, avec 9 cartes *in-folio*.
25. Traité des mesures itinéraires.
26. Etats formés en Europe, avec une carte *in-folio*.
27. L'Empire Turc.
28. L'Empire de Russie.
29. Eloge de M. Gravelot, frère de M. d'Anville, tiré du Nécrologe.
30. Antiquité de l'Inde.
31. Mémoire sur la Chine.
32. Considérations sur la composition des cartes géographiques.
33. Mémoire sur la Mer Caspienne, avec une carte *in-4to*.
34. L'Euphrate et le Tigre, avec une carte *in-folio*. D'Anville.
35. Mémoires sur les cartes de l'ancienne Gaule.
36. Mémoire sur la vallée de Tempé.

The following appeared in the *Transactions of the Academy of Belles Lettres:*

1. Sur le pas militairé du soldat Romain et celui de soldat Français.
2. Sur la nation des Gêtes.
3. Sur les sources du Nil, avec une carte.
4. Sur les rivères de l'Afrique, avec une carte.
5. Sur la mesure du Schène égyptien, avec une carte.
6. Sur la mesure de la terre par Eratosthène.
7. Sur la détermination de plusieurs positons dans le Levant.
8. Découverte d'une cité dans l'ancienne Gaule, avec une carte.
9. Sur un monument ancien de la Médie.
10. Sur la position de Babylone, avec une carte.
11. Description de l'Hellespont, avec une carte.
12. Sur le mille Romain, avec une carte.
13. Sur le Portus Itius, avec une carte.
14. Sur les villes de Taurunum et de Singidunum, avec une carte.
15. Description de la Dace de Trajan, avec une carte.
16. Sur le Li, mesure itinéraire des Chinois.
17. Sur quelques points de géographie dans l'Arabie-heuruse.
18. Sur la différence de latitude et de longitude entre Alexandria et Syéné, avec une carte.
19. Sur le pays d'Ophir, avec une carte.
20. Sur la situation de Tartessus, avec une carte.
21. Sur le Golfe Persique, avec une carte.
22. Sur l'étendue de l'ancienne Rome, avec une carte.
23. Sur les peuples qui habitent la Dace de Trajan.
24. Du rempart de Gog et de Magog, avec une carte.
25. Sur deux villes nommées Justiniana, avec une carte.
26. De la mesure itinéraire Arménienne.
27. Description du Golfe d'Ambracie, avec une carte.
28. Sur l'isle de Cypre, avec une carte.
29. Sur l'expedition d'Héraclius en Perse, avec une carte.
30. Sur la Sérique des anciens, avec une carte.
31. Limites du Monde connu des anciens, avec une carte.
32. Du lac Asphalite, ou Mer Morte, avec une carte.
33. Examen critique d'Hérodote sur la Scythie, avec une carte.
34. Sur la mer Erythrée, avec une carte.
35. Sur l'étendue de Constantinople, comparée à celle de Paris, avec une carte.
36. Des fleuves du nom d'Araxe.
37. Sur la navigation de Pythéas à Thulé.
38. Sur les noms de peuples et de villes cites dans un fragment du 91° livre de Tite-Live, avec une carte.

And the following in the *Transactions of the Academy of Sciences:*

Apiary. Memoire pour corriger la latitude de la Mesopotamie, avec une carte.

We find from a *Notice* in the second volume of that useful Geographical Miscellany—the *Annals du Voyages*, &c. by Malte Brun,—that a complete edition of the works of D'Anville, containing all the memoirs and tracts above enumerated, had been announced for publication at Paris in 1808. The first volume was to be published in that year, and the work was to consist of 6 volumes 4to, with a Folio Atlas. (B.)

APIARY. Under the article BEE, in the *Encyclopædia*, directions have been given at considerable length as to the management of an apiary; and various methods are there detailed of procuring honey and wax from the hive, without destroying the bees themselves. The most economic mode of attaining these ends, deserves more attention as a national object, than it has in general received in this country. It appears, from the returns of the Custom-House, that England pays annually to the North of Germany from L.40,000 to L.50,000 Sterling, for the wax and honey which are imported from thence, and which might very easily be raised by a more extended and judicious cultivation of bees at home. Greater attention to this useful appendage to the Cottage, would not only be productive of commercial advantage, but would tend to improve the condition of the lower order of Peasantry. It is not generally known, indeed, what profitable returns may be obtained, at a trifling expence of time and labour, by very simple processes. Mr Huish, who has lately published a valuable practical treatise on the management of bees, has made a calculation, from which he infers, that even supposing the first cost of a swarm to be one guinea, which is the price in the places where they are sold the dearest, the Cottager is almost certain, by proper care and management, of clearing, in five years, a net produce of nearly L.60; and of having besides, at the end of that period, ten good stocks of bees in his garden.

The principal objects to be attained in the construction and management of an apiary, are to secure the prosperity and multiplication of the colonies;—to increase the amount of their productive labour;—and to obtain their products with facility, and with the least possible detriment to the stock. The apiary should afford to the bees the best shelter against moisture and the extremes of heat and of cold, and especially against sudden vicissitudes of temperature; it should protect them against their numerous enemies; it should afford them every facility of constructing their combs, and of rearing their young; it should allow of every part of the combs being occasionally inspected, and being capable of removal when requisite; and, while due attention is paid to economy, it should be made of materials that will ensure its durability. Much ingenuity has been displayed by different Apiarians in the construction of hives, which should unite in the greatest possible degree all these advantages. Although it be in vain to hope that every one of these objects can at once be perfectly attained; yet there is still great room for improvement on the hives that are at present in common use; and we shall point out, in this Supplementary article, such modes of construction as have been recommended since the publication of the article BEE, above referred to.

Apiary.

While some Cultivators of bees have been chiefly anxious to promote their multiplication, and to prevent the escape of the swarms in the natural way, by procuring what they have termed *artificial swarms*,—which they effected by separating a populous hive, previous to its swarming, into two parts, and allowing to each greater room for the extension of their works; others have contemplated only the abundance of the products which they yielded, and the facility of extracting them from the hive, without showing any particular solicitude as to the preservation of the bees themselves. Another class of Apiarians have, on the other hand, had it more particularly in view to facilitate the prosecution of researches in the natural history and economy of bees. The hive invented by Mr Huber is peculiarly calculated for the last of these objects, and its construction is founded on an accurate knowledge of the habits of these insects. He has given it the name of *Ruche en livre ou en feuillets*, from its opening and shutting somewhat in the manner of the leaves of a book. This *book* or *leaf hive* is composed of from eight to twelve square wooden frames, placed vertically, and joined together sideways like the hoops of a cask. Each frame consists of two uprights, one inch in thickness, a foot in height, and an inch and a third in width, connected by an upper and lower cross bar, ten inches long, and of the same breadth and thickness as the former; so that all the frames may be joined together, without leaving any interval. The two external frames are closed each by a pane of glass, which is covered by a shutter on the outside: and the whole is properly secured in its place, and further protected by an external cover. An aperture must of course be left in the lower part of one of the frames to serve as a door. In order to determine the bees to construct their combs in the plane of each leaf, a small piece of honey-comb is fixed, by means of pegs, to the top of each in the proper position; as it is well known, that bees always complete their work in the direction in which they find it begun, unless they meet with some insurmountable obstacle. A proper distance is thus preserved between the lateral surfaces of the perpendicular combs; and the external ones, being only three or four lines distant from the glass panes, may be easily inspected by opening the shutters: and also, by opening in succession the different divisions of the hive, both surfaces of every comb may at pleasure be fully brought into view. No difficulty is experienced in introducing swarms into hives of this construction; and after the lapse of a few days, when the colony is fully established, the bees will very patiently submit to be daily inspected.

Mr Huber's Hive.

Mr Huber's hive is exceedingly well calculated for producing artificial swarms on the principle of Sebirach's discovery, of which a full account will be given in the Article BEE in this Supplement. It allows us to judge by inspection, whether the population is sufficient to admit of division,—if the brood is of the proper age,—and if males exist, or are ready to be produced, for impregnating the young queen; all

Apiary.

which circumstances are of material consequence to the success of the operation. It is essential, that some of the larvæ should not have been hatched above three days before this attempt is made. The frames must then be gently separated at the middle of the hive, and two empty frames be introduced in the interval between the former; each of these new frames having a partition which closes them completely, so as to enable the two portions to be entirely separated without leaving any opening. The door of that portion, in which the queen happens to be at this time, may remain open; but the one belonging to the other part must be closed, so as to retain the bees that have no queen, prisoners for four-and-twenty hours, allowing still, however, sufficient circulation of air. After this interval of time, they appear to have forgotten their queen; at least they are no longer anxious to seek for her, but bestow all their solicitude in the education of the larvæ, so as to convert a certain number of them into queens to supply the loss they have sustained. This they accomplish in ten days or a fortnight after the operation. The two colonies are now perfectly distinct, and are never found afterwards to intermix.

Another advantage attending a hive of this construction consists in its enabling us to force the bees to produce a much greater quantity of wax than they would naturally do. The interval which separates the combs, when the bees have not been disturbed in their operations, is constantly the same, namely, about four times. Were they too distant, it is evident that the bees would be much dispersed, and unable to communicate their heat reciprocally, and the brood would not be preserved in a sufficient degree of warmth. Were the combs too close, on the contrary, the bees could not freely traverse the intervals, and the work of the hive would suffer. It is evident that we may avail ourselves of this instinct, and by separating farther asunder the combs that are already built, induce the bees either to extend the breadth of those they had begun, or to build others in the interval, if sufficient space be allowed them for this purpose. Thus, by interposing three empty frames, one between every alternate interval of the combs in a hive containing six combs, three additional combs, if the proper season be chosen, will be obtained at the end of a week; and if the weather continue favourable, the operation may be repeated, and the same number of additional combs procured the week after.

The principal obstacles to the general employment of M. Huber's hives are the expence of constructing them, and the greater degree of attention which they perhaps require from the Cultivator. It has also been objected that the flatness of the roof was prejudicial, by allowing the moisture which exhales from the bees to collect at the top, and to fall in drops at different parts, to the great injury of the subjacent contents of the hive. Féburier proposes therefore the employment of frames in the form of a trapezium, so that the roof shall be considerably inclined to the horizon. He borrows this shape from Bosc, whose hive consists, however, only of two boxes joined together sideways, and separable in order to form artificial swarms. This was an improvement upon Gelieu's hive, which was formed of two square boxes united laterally. Delator had recommended a still more simple form than that of Bosc, though less convenient, namely, that of a triangle resting on its base. Mr Ravenel's hive consists of three square boxes instead of two; Mr Scrain's is also made up of three boxes; but they are low and of great length, and are joined endwise: a communication being established between them by apertures made in the divisions which separate the boxes. It is now, however, well established, that partitions of any kind are detrimental to the prosperity of the colony. The same objection applies, though perhaps in an inferior degree, to the system of storied hives, or those which are divided into stories one above another. A great variety of the latter description, however, have been recommended by different Cultivators. In France they are known by the name of *ruches en hausses*. Mr Thorley's improved hive, of which there is an account in the article Bee, is of this class, and Mr Lombard's *ruche villageoise* may also be referred to the same head, although it be of much simpler construction than any other compound hive. Mr Lombard's hive is composed of two parts, a body, and a cover, forming together an elevation of from seventeen to twenty inches, on a uniform diameter of one foot; excepting the upper part, which ought to be convex. The body is formed of bands of straw, similar to that of the cottages in this country. At the top and bottom of the body is placed an exterior band, which forms a projecting border, on each end; the lower one giving the hive a firm station on its pedestal; the upper one contributing to secure the attachment of the cover, or allowing of another similar body being placed above the first, if such an addition should be deemed necessary. At the top of the body, and even with the upper band, is placed a flooring board, made of a light plank, ten inches in breadth in all directions; and the four corners of which are sawed off in such a manner that the breadth along the diagonal measures one foot. This board is fixed by nails inserted in the upper double band, and entering a little into the front. The four openings that are left on the sides are necessary for the passage of the bees, and for the escape of the vapours which are exhaled from them in winter. A flat rod traverses the hive immediately under the board; and projecting from the two sides about an inch and a half, affords handles for lifting the hive, and facilitates the fastening of the cover, which has also a projecting rod, corresponding with that of the hive. At the bottom is an opening, two inches broad, and nine lines in height, for the ingress and egress of the bees. The cover is formed in the shape of a dome, with a vertical handle at the top, and a cross bar at the lower part, by the projecting ends of which it may be tied to the ends of the bar in the body; and which serves also as a support to the combs that are constructed in the cover. For the latter purpose, also, two other bars are placed crosswise, one above the other. All the hives, and all the bases of the covers, are to be made of one uniform diameter, in order that

Hives of other Apiarians.

the hives may, if occasion require it, be placed upon each other, and the covers be adapted to any of the hives that may happen to be at the top.

The *pyramidal hive* of M. Ducouédie, which the inventor extols in his book, entitled, *La Ruche Pyramidale, avec l'art d'établir et d'utiliser les ruches,* &c. as leaving nothing more to be wished for as to the cultivation of bees, differs but little from that of Mr Thorley. A common straw hive is taken, containing a swarm, which is allowed to remain till the spring of the following year; it is then placed on the top of a square box, with which it is made to communicate by a round aperture at the top of the box. In this state, it is termed by the French *la ruche Ecossaise*, or, *ruche de M. de la Bourdonnaye*. On the following spring, a second box is placed under the first, and the whole now assumes the name of *la ruche pyramidale*. The bees are still allowed no other ingress or egress, but by a single hole made in the lowest story. The upper stories may then be removed in succession, while further room is allowed below by the addition of fresh boxes. It is stated by M. Ducouédie, that the bees in his pyramidal hive never perish by hunger or by cold; for they always abound in provisions, and are too numerous to be affected by the most rigorous winter. When the bees are in groupes, they maintain the necessary warmth in the hive, and the brood, on the return of spring, is hatched one month sooner than in any other hive. Mr Huish has, however, made it clearly appear, that these pretended advantages are much exaggerated, while its inconveniences are passed over in silence. It is difficult, if not impossible, to proportion the hives in all cases to the magnitude of the swarms, or to the energy with which they labour. The honey being taken from the oldest cells, is deteriorated by an admixture of pollen, communicating to it a degree of bitterness, of which it is difficult to deprive it; and is less abundant in consequence of the diminished capacity of the cells, in which the coccoons of successive bees in their state of nympha have accumulated. From their being divided into different stories, the bees are obliged to live, as it were, in different families; while their own preservation, and that of the brood, requires them to live in the strictest union. The heat is also lessened by the division of the bees into different groupes. The upper part of these hives, being all necessarily flat (except the first or straw hive), occasions a serious inconvenience, by allowing moisture to collect and drop down into the middle of the hive, instead of trickling down the sides. The injury which this does to the combs, and to the bees themselves, who are constantly exposed to its influence, is, according to Mr Huish, the most common cause of the loss of the hives during the winter. The bees, he observes, always begin their work in the most elevated point of the hive, and seek for that purpose the central part of the roof. If the top be flat, and especially if it be as spacious as in the hives called pyramidal, the bees will not find this centre; they will work one year in one part, and the following year in another. This is, without doubt, one of the causes which obliges a proprietor to wait three or four years before any honey can be gathered from these hives.



The hive recommended by Mr Huish, as affording sufficient facility for examining any of the combs, and performing on them any operation at pleasure, is very similar in form to that described in the *Encyclopædia* (See Bee) as being used in Greece; and of which a figure has been given. The body of the hive is a straw basket in the shape of a flower-pot, that is, of a broader diameter above than below. Eight pieces of well seasoned wood, about eight inches broad, and half an inch thick, are laid parallel to one another, at equal distances, over the top of the basket, and fastened to an outer projecting band: they are then covered with net-work, over which is placed a circular board, or what is better, a convex cover of straw extending over the whole of the top of the hive. This net-work obliges the bees to fasten their combs to the transverse boards; by means of which, each comb can easily be lifted up, without interfering with any other part of the hive, or occasioning the loss of a single bee; and the whole of the interior of the hive is thus open to inspection, and we are enabled to trace the devastations of the moth, or to ascertain the presence of any other enemy.—See the article Bee in this Supplement. (w.)

APPRENTICE. The nature and object of the engagement contracted between the apprentice and his master, has been sufficiently explained in the body of this work. As, however, numerous laws have been passed, particularly in England, for the purpose, not only of guaranteeing the performance of this contract, but of regulating also the terms upon which it should be entered into by the respective parties, and of defining the relative duties of each, it will be necessary shortly to state the most important of these regulations.

In that country, the 5th Eliz. continued for a long period to be the leading statute on this subject; but its regulations were at length found to be fraught with such numerous inconveniences, and to be so ill adapted to the present improved state of the mechanical trades, that, by the 54th Geo. III. several of its most material provisions were repealed. By the 5th Eliz. it was required, in order to give validity to the contract of apprenticeship, that the apprentice should be bound by a regular deed; and, by the custom of some places, it was necessary that the deed or indenture should be enrolled. In London the custom is, that all indentures be enrolled, within a year, before the Chamberlain; and, if this form shall have been neglected, it is enacted that a writ of *scire facias* shall issue upon the petition of the Mayor and Aldermen, to show cause why it was not enrolled. If it shall be found that this omission proceeded from the fault of the master, the apprentice may sue out his indentures, and be discharged; and, if otherwise, the contract ceases to be binding on the master. The 5th Eliz. c. 4, § 25, also provided, that no apprenticeship could be constituted except by indenture; and it was found, that, under a different instrument, a master could not maintain an action against a person for enticing away and detaining his apprentice. The same act provided, that no agreement to execute indentures of apprenticeship should constitute a suffi-

Apprentice. cient binding, although a service of seven years might have been duly performed under it. To give validity to the indenture, it was not only necessary to comply strictly with the provisions of the 5th Eliz.; but every person who engaged apprentices against the terms of that act, was made liable to a penalty of L. 10.

By the common law, every person is left at liberty to follow whatever trade or employment may be agreeable to him. But, as it was supposed that great injury would result to the public if unqualified persons were to exercise the various crafts and mysteries connected with the mechanical trades, it was specially provided, by the 5th Eliz., that no person should exercise any art or craft, unless he had previously qualified himself for it by a regular apprenticeship, under a penalty of L. 400 for every month. Considerable doubts were always entertained as to the trades to which this statute applied; and, as the Courts of law do not seem generally to have favoured the principle of the statute, their decisions tended rather to confine than to extend the restriction. It was at length agreed that the law was only applicable to such trades as existed at the time of passing the act, and to such, also, as implied some mystery or craft. The operations of the statute was also held to be limited to market-towns; it being supposed necessary for the convenience of the inhabitants of country villages, that the same person should exercise different trades, even though he had not been regularly bred by a seven years' apprenticeship to each. These various limitations of the statute gave rise to many very absurd distinctions, which plainly shewed how very unsuitable this antiquated law was to the present advanced state of the mechanical trades. It was found, for example, that a coachmaker could neither himself make, nor employ journeymen to make his coach-wheels, but that he behoved to buy them of a master wheelwright, this last trade having been exercised in England before the 5th Eliz. But a wheelwright, though he has never served an apprenticeship to a coachmaker, might either himself make, or employ journeymen, to make coaches, the trade of a coachmaker not having been prohibited by the statute, as not being exercised in England at the time it was passed. All the great manufactures which, in modern times, have arisen throughout England, in Manchester, Birmingham, Sheffield, Wolverhampton, were, on this account, exempted from the restrictive operation of this law, and the perfection to which they have arrived, seems a practical proof of its inutility for the encouragement of trade.

The effects of those restrictions imposed by the 5th Eliz. were at length felt to be so injurious, that, in the year 1813, petitions were presented to Parliament, from various manufacturing towns, for a repeal of certain parts of this exceptionable statute; and the 54th Geo. III. was accordingly passed, by which all the penalties and prohibitions imposed by the 5th Eliz. on those who should exercise any trade or mystery, unless qualified by six or seven years' apprenticeship, were repealed. That part of the statute was also repealed, which enacted that no person should become an apprentice except in strict conformity to the provisions of the 5th Eliz., and which rendered all indentures contrary to this act null and void. In opposition to this, it was provided, that all indentures, or covenants, which would otherwise be valid, should now be valid, anything in the 5th Eliz. to the contrary notwithstanding.

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In the incorporated trades, bye-laws have generally been enacted, for the purpose of restraining each master to a certain number of apprentices, and those bye-laws have, in many cases, been confirmed by the public laws of the kingdom. In Sheffield, it is a standing rule in the corporation of cutlers, that no master cutler can have more than one apprentice at a time. In Norfolk and Norwich, no master weaver can have more than two apprentices, under a penalty of paying L. 5 per month to the King. The 5th Eliz. c. 4, § 33, enumerates various trades in which the master is obliged, under a penalty of L.10, to keep one journeyman for every three apprentices. No master hatter can have more than two apprentices anywhere in England, or in the English plantations, under a penalty of L. 5 per month. Most of these statutes, however, are now so ill adapted to the state of trade and manufactures, that in practice they are very generally evaded.

The engagement contracted between the master and apprentice is entirely of a personal nature, arising from the confidence they mutually place in each other; the master engaging to instruct the apprentice in his business, and to take care of his health and morals, while the latter engages, in like manner, for a return of faithful and diligent service. The transaction thus rests on the personal qualities of the two parties, and indentures are, therefore, not transferable to third persons. By the death of the master the contract is annulled, and a new engagement, with another master, can only be entered into by the consent of the apprentice. A different custom, however, prevails in London, where one freeman can transfer his apprentices to another freeman, without any injury to the original engagement. Where the maintenance of an apprentice forms one of the conditions of his service, the death of the master does not dissolve this obligation, his executors being bound to discharge it in so far as it can be done out of the effects left by the deceased. By the 32d Geo. III. (c. 57, § 5,) parish apprentices may, with the consent of two justices, be assigned over, by indorsement of their indentures, to third parties; and the person declaring his acceptance of the assignment, shall be bound to perform all the duties of a master to the apprentice, for the residue of his term. Where the master of a parish apprentice dies, upon whose binding no larger a sum than L. 5 has been paid, it is provided, that the covenant for maintenance of the apprentice shall not remain longer in force than three months.

A master is entitled by law to use moderate chastisement in the event of any misbehaviour on the part of the apprentice. But he has no right to treat him with any unnecessary harshness; and in that case, by the 20th Geo. II. c. 19, § 3, he may, on the complaint of any parish apprentice, or of any other apprentice, on whose binding there is no larger a sum than L. 5, be summoned before any two justices, and,

Apprentice. on proof of the alleged facts, the apprentice may be discharged by a certificate under the hands of the justices. In like manner, by § 4, on the complaint of the master on oath, of misbehaviour on the part of the apprentice, he may be summoned before the two justices, who may commit him to the house of correction to hard labour for any time, not exceeding a kalendar month, or they may, as in the former case, sign a certificate for his discharge. By § 5, either party has the privilege of an appeal to the next Quarter Sessions. If an apprentice, with whom a premium under L. 10 has been paid, shall absent himself from his master's service, it is provided, by the 6th Geo. III. c. 25, that he shall either serve for so long a time beyond the period of his service, or make any other suitable satisfaction to his master for the loss of his labour. In case of his refusal, he may be apprehended, and brought before a justice, who may determine the satisfaction that shall be made; and, on his refusal to comply with this determination, he may be committed to the house of correction for three months. The master may make application for compensation within seven years after the expiration of the term of apprenticeship. Either party may appeal against the decision of the justices to the Quarter Sessions.

By the common law, minors may bind themselves out as apprentices, and if they serve out their regular term, they are entitled to all the privileges of apprentices. But no minor can contract such an obligation as will entitle the master to maintain an action against him, provided he either departs from his service, or commits any other breach of his engagement. He may indeed correct him in his service, or complain to a Justice of the Peace to have him pursued according to the 5th Eliz. But no remedy lies against a minor for breach of any such covenant. The children of paupers may, however, be apprenticed out by the overseers, with consent of two Justices, and in this case (5th Eliz. c. 4; 43d Eliz. c. 2. Cro. Car. 179.), the indenture is obligatory, though the apprentice be under age. In consequence of the incapacity of the minor to enter into any regular contract of apprenticeship, the usual practice is to procure some of his friends to become surety for his due performance of the engagement into which he enters. According to the custom of London, a minor above the age of fourteen, may bind himself apprentice to a freeman in London by indenture, with proper covenants, and these covenants are in law equally binding as if he were of full age.

Indentures were formerly subject to a variety of duties which were imposed by successive acts, and these duties necessarily gave rise to a series of intricate enactments, which frequently occasioned much perplexity and inconvenience. By the 44th Geo. III. c. 98, § 8, all those numerous duties were consolidated into one simple duty on the stamp, which varies from 14 shillings to 19 guineas, according to the premium which is paid with the apprentice. By the 43d Geo. III. c. 161, an annual duty is imposed of L. 1, 1s. on every apprentice who pays a premium above L. 20.—See Jacob's *Law Dictionary*.—Smith's *Wealth of Nations*, with Notes, and an additional volume of Dissertations, by David Buchanan. (O.)

Apprenticeship. APPRENTICESHIP. The *Encyclopædia* contains an account of the rules by which apprenticeships are regulated in different countries, together with a view of the objections urged by Dr Smith, against the utility of the engagement concluded between the apprentice and his master.

Dr Smith considers the institution of apprenticeships as a device, by which trading corporations endeavour to confine to as few hands as possible the mystery of their craft, and by which, keeping the market always understocked with their particular sort of labour, they expect to regulate according to their discretion the price of such manufactures as they bring to market. He accordingly condemns all those laws which limit the number of apprentices, to be taken by each master in particular trades, or which prescribe to apprentices a certain term of service before they are permitted to work as journeymen. The tendency of such laws, he observes, is to restrain the competition to a much smaller number than might otherwise be disposed to enter into the trade; the limitations of the number of apprentices restraining it *directly*, and a long apprenticeship restraining it *indirectly*, but as effectually, by increasing the expence of education. Long apprenticeships, or indeed any apprenticeship, for however short a term, Dr Smith considers quite unnecessary, as the nicest mechanical arts, such as the making of clocks and watches, contain, according to his theory, no such mystery as to require a long course of instruction. A few weeks, he calculates, or even a few days, would be sufficient to enable a mechanic to set to work in any of those trades; and if he were paid the full price for his work, he paying of course for such materials as he might spoil through awkwardness and inexperience, he imagines that he would learn his business more effectually, and be more apt to acquire habits of attention and industry, than when he works under a master who has a right to share in the produce of his labour.

It may be generally remarked, however, that, in his reasonings on these subjects, Dr Smith seems uniformly disposed to overrate the practical effect of those expedients by which corporations have been always endeavouring to secure special advantages for particular trades; and that his theory respecting apprenticeships is only a part of that more general theory, by which he endeavours to show that the policy of Europe has always been to encourage the industry of the towns at the expence of that of the country; and that the effect of this policy has been to enable the merchants and manufacturers of the town, in bartering their produce for that of the country, to levy, for several centuries, an unjust and oppressive tax on the agricultural classes of the community. We know, however, that, according to the nature of human society, as it is so admirably explained in Dr Smith's work, monopoly can never succeed on so great a scale; and, on the same principle, we may rationally question if the contract between the apprentice and his master were merely the device of corporations, whether it ever could have come into such universal use throughout Europe. The engagement by which the apprentice is bound to his master, is his own voluntary act. He agrees to bind himself to work to his master at an inferior rate, on condition

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of receiving from his master the necessary instruction in his business. This instruction, Dr Smith asserts, may be given him in the course of a few days or weeks. It is well known, however, to every practical tradesman, or to any one acquainted with the nature of mechanical employments, that the instruction of three days or weeks would scarcely teach an apprentice the name of his tools, and that almost all the mechanical trades require, throughout their various operations, such nicety and exactness, that the necessary habits are not formed by the training of years, in place of weeks or days. It is for the troublesome superintendence of the apprentice during this period that the master exacts compensation, without which he would employ none but finished workmen. But he puts up with the awkwardness of his apprentice, because he expects to be benefited by his labour after he shall be better instructed in his business; on the same principle that the farmer lays out his capital on the improvement of his land, in expectation of a future increase of produce. The contract of apprenticeship is thus a voluntary agreement between two parties for their mutual benefit, the result neither of law nor of the usages of petty corporations, but of circumstances. The law, indeed, takes cognizance of the contract, and enforces its fulfilment; and it may also have encumbered it with absurd regulations. But the contract itself stands independent both of law and usage, having its origin in the plainest principles of reciprocal expediency. There seems no reason therefore to class it with those artificial expedients which originate in the exclusive spirit of trading corporations.

Dr Smith appears also to have greatly overrated the effects of those laws, the object of which is to limit the number of apprentices which shall be reared to particular trades. No law of any corporation will ever be found in practice to impose any limitation on the number of apprentices which will be trained to a business. It will depend on the state of the business, whether it is advancing, stationary, or declining, what number of apprentices will be bred to it; and if, while a flourishing trade called for a continual supply of new hands, any corporation were to enact a law, limiting the masters to such a number of apprentices as would barely keep up their present stock, a scarcity of hands would soon be felt, wages would rise, and the masters would soon be induced, by regard to their own interest, to rescind the law which imposed so great an inconvenience on themselves. But if the law is thus modified and accommodated to the state of the trade, it is a mere form. It imposes in reality no restraint, since it is always in the power of the masters to alter it whenever they feel that it interferes with their arrangements.

But though the law were even rigidly persisted in, it is evident that it would not permanently diminish the number of apprentices, which would be bred to a business, since the consequence would be, that the workmen would turn masters, and each taking the full allowance of apprentices which the law permits, would soon train up an ample supply of hands. All those petty contrivances of corporations, therefore, though they may originate in the lowest mercantile jealousy, and though they may be exceedingly absurd, cannot materially disturb the general progress of things; and, though they may harass individuals, their effect on the industry of a great country hardly deserves notice; their bad effects being corrected by those general causes on which society depends for completing its arrangements, in spite of the obstacles arising from the mistaken policy of legislators.—See Smith's *Wealth of Nations*, with Notes, and an additional volume of Dissertations, by David Buchanan. (o.)

Aqua Tofana.

AQUA TOFANA, called also *Aqua della Toffanina*, or *Aqua della Tofa*, from its supposed inventress,—*Aqua del petesino*,*—*Aquetta di Napoli*, or simply *Aquetta*,—a poisonous liquor which was used to a very great extent at Naples and Rome during the latter half of the seventeenth century. Gmelin † says, that more people were destroyed by it than by the plague, which had prevailed a short time before it came into use; and Garelli, chief physician to the Emperor, wrote to Hoffmann that Tofania confessed she had used it to poison more than six hundred persons. This he learnt from the Emperor himself, to whom the whole criminal process instituted against her was transmitted.‡

It is to be regretted, that Garelli, who had such an authentic source of information, has not given us some details of the infamous Tofana or Tofania; as the little that we know of her rests upon the authority of travellers, and is evidently exaggerated, and sometimes irreconcilable with established facts. She was a Sicilian by birth, and resided first at Palermo, and then at Naples. When she began to exercise her horrible profession, is nowhere stated; but it will presently appear, that it must have been at a very early age, and before 1659. She was extremely liberal of her preparation, chiefly it is said, to ladies tired of their husbands; and the better to conceal the nature of her gift, it was put up in small flat phials, inscribed *Manna of St Nicholas of Bari*, ornamented on one side with an image of the Saint, that it might pass for a liquid said to drop from his tomb at Bari, which was in great request on account of the medicinal virtues ascribed to it. Nor is it ascertained how long she carried on her murderous practices with impunity and undiscovered. Labat § says, that when he was at Civita Vecchia in 1709, the Viceroy of Naples, then Count Daun, made the discovery. It was long before she was secured, as she was extremely cautious, and often changed her abode or retired into Convents. At last she was betrayed, and, although in a Convent, was seized and carried to the *Castel del Uovo*, where she was examined. Cardinal Pignatelli, then Archbishop of Naples, indignant at the violation of a religious sanctuary, threatened to excommunicate

* Lanzoni *Opera*, 4to, Laus. 1738, Vol. I. p. 69.

† *Allgemeine Geschichte der mineralischen Gifte*, 1st edit. 8vo, Nurnberg, 1777, p. 132. 2d edit. 8vo, Erfurt, 1811, p. 243.

‡ F. Hoffmanni *Med. Rat. Syst.* P. II. cap. ii. § 19. *Opera Omnia*, 6 vol. folio, Genevae, 1748, Vol. I. p. 198.

§ *Voyage en Espagne et en Italie*, 8 tomes 8vo, Paris, 1730, Vol. IV. p. 33.

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the whole city, if she was not delivered up to him, and the people were ready to rise. But the sagacious Viceroy caused a report to be spread, that she and her accomplices had determined upon the same day, to poison all the springs in the city, the fruits brought to market, and the public granaries. The manœuvre succeeded. The credulous people were now clamorous for her punishment, and saw with satisfaction the persons whom she accused of having purchased her *Aquetta*, taken from the Churches and Monasteries. Some of inferior birth were executed publicly; those of higher rank secretly in prison; and the whole city resounded with the praises of the Viceroy, whose energy had saved it from general destruction. A kind of compromise was entered into with the Cardinal; in consequence of which, after being strangled, her body was thrown at night into the court of the Convent, by way of testifying some respect for the rights of the Church. But the reverend traveller must have either been misinformed as to the actual execution of this Medea, or she must have been resuscitated; for Garelli expressly says that she was alive in prison at Naples, when he wrote to Hoffmann, not long before 1718; and Keysler, who visited Naples in 1730, * likewise asserts, that she was then living in prison, and that few strangers left the city without going to see her. He describes her as a little and very old woman.

The Roman ladies very quickly availed themselves of Tofania's dicovery; for it was remarked in 1659, that many husbands died when they became disagreeable to their wives; and several of the clergy also gave information, that, for some time past, various persons had confessed themselves guilty of poisoning. This led to the detection of a society of young married women (who had, for their president, an old woman of the name of *Hieronyma Spara*, a pretended fortune-teller), as the perpetrators of these murders. On being put to the torture they all confessed except Spara, who seemed to rely upon the protection of powerful individuals whom she had formerly served. But she was left to her fate, and was hanged along with her assistant, one *Gratiosa*. Others were afterwards hanged, or whipt and banished. Spara, who was a Sicilian, had acquired her knowledge from Tofania at Palermo. †

Pope Alexander VII., immediately on the discovery and punishment of those who dealt in poison in his capital, published an edict forbidding the distillation of aquafortis, or the purchase of any of its ingredients, without the permission of the Government; which Gmelin considers as an artifice to mislead the people as to the real composition of the poison, or as originating in the absurd nomenclature of the Chemists of former times, who called arsenic, concrete aquafortis. But the prudence of the Pope was rendered fruitless; for we are informed by Gayot di Pitaval (*Causes Celèbres*, Vol. I. Amsterd. 1764, p. 317.), on what authority he does not state, that Tofania's fatal secret was disclosed by the indiscretion of the judges at Naples, to whom she had made confession of her crime. The whole city soon knew that she employed in its composition a very common herb, and that its preparation was otherwise easy; and in this way the art of poisoning became very common in Naples, where, Keysler says, it was still secretly practised when he visited Italy; and Archenholz, ‡ who was there in 1780, states, that Aqua Tofana was then in use, although its composition was only known to a few; but Joseph Frank, who was long Professor in Pavia, and has written a work on toxicology (*Handbuch der Toxicologie*, Wien, 1803, p. 168.), regards this as an unfounded calumny, and asserts that it no longer exists or is heard of.

Aqua Tofana is described as being as limpid as rock water, and without taste, and hence it could be administered without exciting suspicion. The Abbé Gagliani adds, ‖ that there was not a lady in Naples, who had not some of it lying openly on her toilet among her perfumes, in a phial known only to herself.

It was generally believed, that the effect of this poison was certain death; and that it could be so tempered or managed, as to prove fatal in any determinate time, from a few days to a year or upwards. Four or six drops were reckoned a sufficient dose, and they were said to produce no violent symptoms, no vomiting, or but very seldom, no pains, convulsions, inflammation, or fever; § but only a feeling of indisposition, without any very definite symptoms, except sometimes inextinguishable thirst; the victim, however, sunk into a languid state, and his weakness increased daily. Disgust at all kinds of food, and weariness of life, succeeded; the nobler organs were then attacked, the lungs were wasted by suppuration, and death closed the miserable scene. This termination was the more certain, that the true cause of these symptoms was not at first suspected, and the remedies commonly prescribed rather aggravated the evil. Indeed, even when known, no treatment was of any avail, although a Dr Branchaletti, according to Keysler, wrote a book on its remedies, until it was discovered by accident that lemon-juice, when very early administered in large doses, sometimes proved effectual (Bertholinus), after which, Keysler tells us, that the poison fell into some disrepute.

Various accounts of the composition of this detestable liquor have been given. Abbé Gagliani, and more lately Archenholz, state it to be a prepara-

* *Travels through Germany, &c.* 4 vols. 4to. 2d edit. London, 1756, Vol. II. p. 368.

† J. F. Le Bret, *Magazin zum Gebrauche der Staaten-kirchengeschichte*, IV. Frank. 1774, p. 131—141, as quoted in the curious chapter on *Secret Poisons*, in Beckmann's *History of Inventions and Discoveries*;—a work which has been of great assistance to us in pointing out authorities.

‡ *England und Italien*, 5ter Theil 8vo, Carlsruhe, 1787, p. 184.

‖ Weckherlin's *Chronologen*, 12ter Band, p. 146—*L' Espion Dévalisé. Feliciter Audax*, London, 1782, p. 61; also Behrends, in Pyl's *Magazin für gerichtliche Arzneikunde und medicinische Polizey*, B. I. St. 3. 1784, p. 428-477.—Beckmann.

§ Bertholinus alone enumerates very violent fever as its first effect. See J. J. Wepferi *Historia Cicutæ Aquaticæ*, 8vo. L. Bat. 1733, p. 372.

tion of cantharides and opium; but this is perfectly inconsistent both with its appearance and effects. By no preparation can the smell and taste of opium, if the quantity be sufficient to produce any effect, be concealed, and the acrimony of cantharides is equally connected with its activity. The one of these drugs is highly stimulant, the other a sedative, and neither of them capable of remaining latent in the system, or injuring the constitution. Erndtel,* but without any probability, has conjectured that the chief ingredient was lead: Halle (*Die deutchen Giftpflanzen*, Berlin, 1783) believes, that it was prepared from the frothy saliva gathered round the mouth of a person tortured to death. Garelli, on the contrary, positively asserts it to have been nothing but a solution of crystallized arsenic in a large quantity of water, with the addition, for some unknown reason, of a very innocent herb, the *Antirrhinum cymbalaria*. The same account is given by Bertholinus, Lobel (*Der freymüthige Heilkunstler*, Berlin, 1786), Plenk (*Toxicologia*, p. 335), Haller,† Molitor (*Commerc. Lit. Noric.* 1737, p. 182), and Möhsen,‡ and is received by the most judicious systematic writers, as Gmelin and Hahnemann. (*Ueber die Arsenikvergiftung*, 8vo, Leipzig, 1786, p. 35.) Wildberg,‖ however, considers its composition to be unknown.

From Italy this poison seems to have found its way to Paris. In 1672 Godin de Sainte Croix, an adventurer, who lived in a scandalous intimacy with the Marchioness Brinvilliers, was suddenly killed by suffocation, as it is said, in consequence of the falling off of a mask of glass, which he wore to protect him from the fumes of certain chemical operations about which he was employed. As he had no known relations, his effects were examined by a public officer, and among them was found a casket, containing many packets of poisonous articles, sealed up in a mysterious manner, together with a kind of last will, directing the whole to be delivered to the Marchioness, and, in case of her having predeceased him, to be burnt unopened. This led to the discovery of his having been instructed in the art of preparing poison, by an Italian, called Exili, with whom he had become acquainted, when confined in the Bastille; and of his having furnished the Marchioness with the means of poisoning her father and her two brothers, besides others on whom she tried the effect of her preparations. One of these afterwards was called from her by the name *Eau de Brinvilliers*. She is also said to have employed a powder called *Poudre de Succession*.§ La Chaussée, who had been valet to Sainte Croix, was convicted of being accessory to these murders, and was broken alive on the wheel. The Marchioness herself, who had escaped to Liege, was also seized, and her execution, which took place on the 17th of July 1676, is described with revolting levity by Mad. de Sevigné in a letter to her daughter of that date.

The practice of poisoning, however, did not seem to terminate with the death of this infamous woman; and a particular court called *Chambre des Poisons*, or *Chambre Ardente*, was established in 1679, to endeavour to put an end to it. In consequence of the investigations which took place in it, many persons, some of the highest rank, especially the Duc de Luxembourg, were implicated. More than forty persons were at one time confined in the Bastille; but it was ascertained, that almost all of them had been guilty of no crime, but were merely the dupes of a few impostors, who pretended to raise spirits, foretell future events, and to possess many secrets of a similar nature. Two women, La Vigoureux and La Voisin, with the brother of the former, and a priest called Le Sage, ¶ pretended fortune-tellers, were convicted of being dealers in poison, and burnt alive, on the 22d Feb. 1680; some others were hanged, and others acquitted. This closed the proceedings of this inquisitorial court, which has been accused of being a political engine, contrived to serve the purposes of Louvois and the Marchioness de Montespan. Voltaire, however, admits that the crime of poisoning infected Paris from 1670 to 1680.

Concerning the effects of the *Eau de Brinvilliers*, Pitaval tells us (p. 271.) that the Marchioness's father experienced violent effects from the poison,—extraordinary vomiting, insupportable pain at stomach, and great heat in the bowels. He died soon after his return from his country-seat to Paris. The brothers, and five other persons, were all taken ill, and affected with vomiting, after partaking of a tart at dinner. On their return from the country to Paris, the brothers had the appearance of persons who had been long ill; and after suffering, the one for two, and the other for three months, from nausea and vomiting, they died extremely emaciated, and as it were dried up, without fever, though experiencing a burning sensation in the stomach. On opening the bodies, the stomach and duodenum were black and tender, and the liver gangrenous and burnt. Mad. Sevigné relates, that the Marchioness often poisoned her husband, that she might marry Sainte Croix, but that the gallant, having no desire for a wife of her disposition, as often gave the poor husband an antidote. She is also said to have attempted to poison her sister; but did not succeed; and that she was in the habit of trying the effects of her poisons on the

* *Dissert. de Veneno salutem sistens*, Lipsiæ, 1701, § 21.

† *Vorlesungen über die gerichtliche Arzneikunde*, 2ter Band, p. 190.

‡ *Beschreibung einer Berlinischen Medallien-sammlung*, 1. Th. p. 148.

‖ *Handbuch der gerichtlichen Arzeneywissenschaft*, 8vo, Berlin, 1812, p. 224.

§ Heucher, *Mithridates, sistens præservationem Principis a veneno*, vide ejus Opera, 4to, Lipsiæ, 1745, Vol. I. p. 421; *also*, J. G. Arnold pr. C. G. Stentzell *De Venenis terminatis et extemporaneis, quæ Galli* les Poudres de Succession *vocant*. This powder was probably an arsenical composition; but it was supposed by Erndtel and Haller to be acetate of lead, and by Brendel (*Institutiones Medicinæ Legalis*, Halae, 1768) to consist of lead and bismuth.

¶ Voltaire, *Siècle de Louis XIV.* chap. 26.

poor, and even on the patients in the Hotel Dieu, under pretence of charitably supplying them with biscuits. But Voltaire positively denies this horrible imputation, and says, that she never attempted the life of her husband, who overlooked a connection, of which he was the cause.

The information concerning the nature of the *Eau de Brinvilliers*, derived from the examination of Sainte Croix's famous casket, is not satisfactory. It contained poisons enough to have killed a whole community; besides opium, lunar caustic, antimony and vitriol, more than 75 lbs. of corrosive sublimate, and two bottles of a liquid, like water, with a sediment in one. The clear liquid was probably his real poison; as none of the other substances could have been given so as to produce death, without instantly being detected, by their abominable taste; but what this liquid was, we can now only conjecture, for its examination, as reported by Pitaval, shows that the physicians, at that time, had not the slightest notion of the mode of detecting arsenic even in substance, much less in solution; and accordingly, although both the liquor and powder killed the animals to which they were given, it is candidly admitted, that the poison of Sainte Croix surpassed the art and capacity of the physicians, and that it baffled all their experiments to discover its composition. We have, however, no doubt, that arsenic was the only active ingredient of all these pretended secret poisons; as it is the only substance capable of explaining all the credible circumstances related of them. From the mode of administering them in small, but repeated and perhaps increased doses, there was some foundation for the belief that they could be given so as to kill in any determinate time, while their failing in any instance to produce death, was easily accounted for by supposing antidotes to have been administered. But although the progress of knowledge has proved, that there is no such thing as such antidotes, it has on the other hand, by rendering the detection of poison easy and certain, put a stop for ever to the trade of *poisoner;* and what is perhaps of equal importance, to the general alarm and cruel punishment of individuals which have often resulted from natural deaths being ascribed to poison. It is not because we know less, but because we know a great deal more than our forefathers, that the art of secret poisoning seems to be lost.—See Forensic Medicine in this Supplement. (x.)

ARACHNIDES. A class of animals of the type Annulosa. See *Index* to Annulosa.

History.

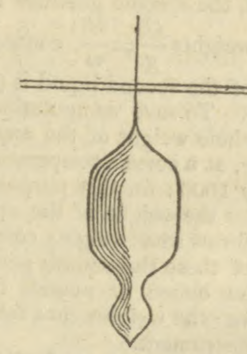
ARÆOMETER (composed of ἀραιος, *levis, tenuis,* and μετρον *mensura*), a measure of the comparative density and rarity of bodies. The name does not occur in ancient authors; hydroscopium and baryllium being the ancient names of the instrument. This instrument was known in the civilized part of the Roman empire, about the year 400, as appears from the fifteenth epistle of Synesius, addressed to Hypatia, daughter of Theon; and to Hypatia some modern writers have erroneously ascribed its invention. The instrument is also described in some verses annexed to Priscian; and the principles on which its operation is founded, are to be seen in the treatise of Archimedes on floating bodies *(De Humido Insidentibus)*. The term, as used by writers on natural philosophy, is chiefly applied to instruments which are made to float, so as to indicate the specific gravity of the liquids in which they are placed: the *pêse liqueur*, and hydrometer, in common use for measuring the specific gravity of vinous spirits, are instruments of this kind.



Theory.

A floating body displaces a portion of the liquid, the weight of which is equal to its own weight, the liquid acting upwards with a force equal to this weight, and the weight of the body acting downwards with the same force, equilibrium takes place. If the body be afterwards placed in a liquid of less density, the part of the body immersed, will be greater than when the body was in the more dense liquid, because it requires a greater volume of this less dense liquid to equal the weight of the floating body. The absolute weights of two bodies being the same, their specific gravities are in the inverse ratio of their volumes $\frac{G}{g} = \frac{v}{V}$, when $G$ is put for the specific gravity of the first body, $g$ for that of the second; $V$ for the volume of the first, and $v$ for the volume of the second. On this principle the common hydrometer is constructed; the instrument described by Synesius, is also of this kind. In order that a small difference in the volume immersed may be sensible, the part which is intersected by the surface of the fluid is in the form of a very slender cylinder, the great bulk of the instrument being always immersed in the liquid. At the inferior part is a small ball, containing mercury or small lead shot, which serves as ballast, bringing the centre of gravity low, so that the instrument may float erect, and without much lateral oscillation. The common hydrometers are made of glass, and sometimes of brass, or tin or pewter, and some have been made of amber as objects of curiosity: when made of glass, a scale, inscribed upon paper, is inserted in the cylindrical stalk; the division of the scale at which the surface of any liquid intersects the stalk, denotes the specific gravity of that liquid.

Aræometer with Scale.



Mode of forming the Scale.

The divisions of the scale should be formed by immersing the instrument in liquids of known specific gravity, and marking a number corresponding to that specific gravity opposite to each division. The specific gravities of water and alcohol mixed in various proportions, have been accurately ascertained by Mr Gilpin (see his Tables, and Dr Blagden's paper in the *Philosophical Transactions*); on immersing the instrument in a mixture of known proportions of these two liquids, the point at which the surface intersects the stalk, is to be marked with the number expressing the specific gravity of the mixture taken from the table. Some hydrometers, such as that constructed by the French chemist Beaumè, and which is much used in France under the name of *Aréometre de Beaumè*, have the

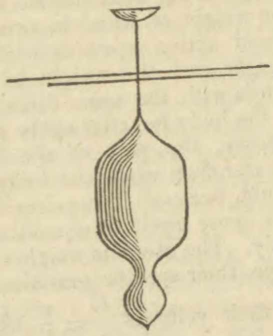
A R Æ

Aræometer.

scale divided into equal parts, so that the divisions do not correspond as they ought to do with the numbers which express specific gravities.

Fahrenheit's.

In the aræometer of Fahrenheit, the uncertainty arising from the erroneous division of the scale is obviated, no division being required. The form of the instrument is the same as that just described, only at the top there is a small cup, into which weights are put, so as to bring the surface of the denser liquid to a fixed mark on the stalk; when the instrument is placed in a liquid of less density, some of the weights are taken out till the mark again comes to the surface.



Manner of using it.

Suppose the weight of the instrument and of the weights in the cup together equal to 1000, when sunk to the mark in distilled water at a certain temperature; the instrument is now taken out of the water and immersed in a liquid, where 10 must be taken out of the cup in order to bring the mark to the surface; the immersion in water indicates that a volume of water weighs 1000; the immersion in the second liquid, shows that an equal volume of this liquid weighs 990; when the volumes of bodies are equal, the specific gravities are directly as the absolute weights $\frac{G}{g} = \frac{W}{w}$, consequently the specific gravity of the second liquid is 990, that of water being 1000.

Construction of the Weights.

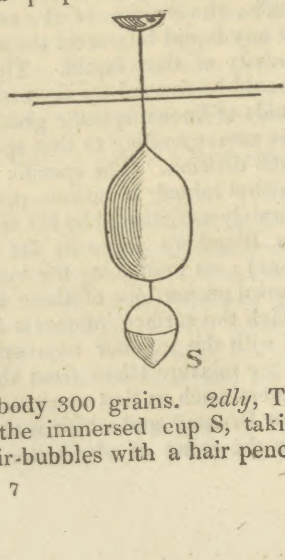
To save computation, it is convenient that the whole weight of the apparatus, when in distilled water, at a certain temperature, should be represented by 1000; for this purpose, the instrument-maker divides the weight of the apparatus into 1000 parts, and forms small weights consisting of one, two, three, &c. of these thousandth parts, the relation of which to the ounce or pound, does not require to be known; the weights thus formed are to be used with the instrument.

Nicholson's.

The aræometer of Nicholson is like that of Fahrenheit, with the addition of an immersed cup, whereby it is rendered proper for ascertaining the specific gravity of solids.

Mode of using it.

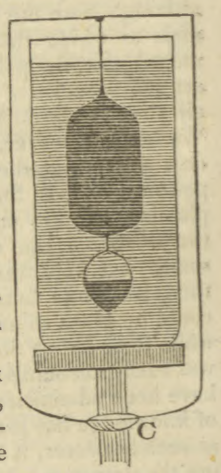
Suppose that it requires 400 grains in the exterior cup to sink the instrument to the mark in distilled water, at 60 degrees of Fahrenheit's thermometer; 1*st*, The body under examination is put into the exterior cup, and weights (say 300 grains) are taken out till the mark again stands at the surface; this gives the absolute weight of the body 300 grains. 2*dly*, The body is then put into the immersed cup S, taking care to brush off any air-bubbles with a hair pencil,




Aræometer.

and in order to bring the mark to the surface, a weight (say 100 grains) must be put into the exterior cup, that is, the weight of a volume of water equal to the body, is 100 grains. The first part of the process gave the absolute weight of the body 300 grains, and the volumes being equal, the specific gravities are as the absolute weights, consequently the specific gravity of the body is 300, that of water being 100. This aræometer may be used to find the specific gravity of liquids; the process, in that case, is the same as that described above in speaking of the aræometer of Fahrenheit. The aræometer of Nicholson is useful to the mineralogist for ascertaining the specific gravity of minerals; the specific gravity being a convenient character for distinguishing one kind of mineral from another. It is sometimes made of tinned iron, but where more accuracy is required, copper is the material employed. When put together, it does not exceed a foot in length, and therefore is suited to form a part of the travelling mineralogist's apparatus.

Some aræometers have been constructed with the exterior cup C placed underneath, and supported by a stirrup, whose upper part is fixed to the stalk of the aræometer, as represented on the margin; this is done in order to place the centre of gravity low, that the aræometer may thereby float more steadily. The aræometer floats in a cylindrical vessel fitted to the size of the stirrup, and this vessel is supported on a stand so formed as not to interfere with the free motion of the stirrup.




Deparcieux's.

The aræometer of Deparcieux is like the common hydrometer, only the ball is much more voluminous; this renders it capable of indicating the small difference which exists in the specific gravity of the water of different springs, for which purpose Deparcieux proposed it. The dilatation of the large glass bulb by heat, has a considerable effect on the operation of this instrument, and this dilatation being different in different instruments, renders the results inaccurate. The different aræometers above-mentioned, have the advantages of being easily made and easily carried about; but where the specific gravity of a body is required with the greatest accuracy, recourse must be had to the hydrostatic balance, which ought to be constructed with the utmost care by the most skilful artist.

Formula.

The following algebraic expressions may serve to elucidate some of the properties of the aræometers hitherto spoken of:

$g$ is the specific gravity of water, which is 1000 ounces when the ounce and foot are taken as unities, 1000 ounces avoirdupois being the weight of a cubic foot of water.

$z$ is the diameter of the wire-stalk of the aræometer.

$\pi$ is 3.1415, &c. the number expressing the periphery of a circle whose diameter is 1.

Aræometer.

$\frac{1}{4}\pi z^2$ is the surface of a transverse section of the wire-stalk.

$v$ is the volume of the bulb or body of the aræometer.

$w$ is the whole weight of the aræometer.

$x$ is the length of the stalk that is plunged in the water.

$\frac{1}{4}x\pi z^2$ is the volume of the immersed portion of the stalk.

When the aræometer floats in equilibrio, it displaces a volume of water equal to its own weight, therefore, $w = g\ (v + \frac{1}{4}x\pi z^2)$, and, $g = \frac{w}{v + \frac{1}{4}x\pi z^2}$, $x = \frac{4(w - gv)}{2g\pi z^2}$; $w - gv$ is the difference between the quantity of water displaced by the whole aræometer, and the quantity displaced by the bulb alone, $w - gv$, therefore, is the volume of water displaced by the immersed portion of the stalk, as the diameter of the stalk $z$ is very small, the cylinder of water $w - gv$, which has $z$ for its diameter, is likewise very small, and does not exceed a few grains in weight; therefore, a small variation in $w$ (the weight of the aræometer), or in $g$ (the density of the liquid), occasions a great variation in $x$ (the length of the immersed part of the stalk). The value of $x$ changes rapidly, when $z$ (the diameter of the stalk) is changed, because the value of $x$ is divided by $z^2$, which is the square of a very small quantity.

Sensibility to the sp. gr. of Liquid.

When the aræometer is immersed in a liquid of another specific gravity $g^1$, then the equation is $x^1 = \frac{2(w - g^1 v)}{g^1 \pi z^2}$; subtract the value of $x^1$ from that of $x$, and there results $x - x^1 = \frac{2w(g - g^1)}{gg^1\pi z^2}$; this is the diminution in the length of the immersed part of the stalk, which takes place when the aræometer is transferred to a liquid of a greater density. By this formula, it is seen, that the sensibility of the aræometer, that is, the length of the portion of the stalk which emerges upon transferring the aræometer to a denser liquid, is augmented, in the first place, by increasing $w$ (the weight of water displaced by the aræometer), that is, by increasing the volume of the body of the aræometer; secondly, by diminishing $z$ (the diameter of the stalk), which is in the denominator of the value of $x - x^1$. Consequently, the faculty of the aræometer to show the different densities of liquids is, in general, expressed by the fraction $\frac{w}{z^2}$.

Expression of the Sensibility to additional Weight.

With regard to the vertical mobility of the aræometer, when put in motion by placing a small weight ($s$) in its exterior cup, substitute $w + s$ for $w$, then, $x^1 = \frac{4(w + s - gv)}{2g\pi z^2}$, take the difference between this and $x = \frac{4(w - gv)}{2g\pi z^2}$; this difference is $x^1 - x = \frac{4s}{g\pi z^2}$. Which shows that the length of the portion of the stalk that a small weight causes to immerge, is proportional to $\frac{s}{z^2}$, or in the direct ratio of the small weight, and in the inverse ratio of the square of the diameter of the stalk.

Expression of the Diameter of the Stalk.

When the small weight, the density of the liquid, and the length of that part of the stalk which is submerged on adding the small weight, are known, then this equation will give the diameter of the stalk in known quantities $z = 2\sqrt{\frac{s}{g\pi(x^1 - x)}}$.

Density of a liq. expr. in terms of $w$.

When the weight of the whole aræometer is known in ounces, &c., and the specific gravity of one of two liquids (water for instance) is known, the difference of specific gravity between that liquid and another liquid may be had in known quantities.

$g$ is the specific gravity of water.

$g^1$ is the specific gravity of the second liquid, which is here supposed more dense.

$w$ is the weight of the volume of water displaced by the aræometer.

$s$ is a small additional weight placed on the exterior cup to keep the aræometer, when placed in the denser liquid, at the same point of immersion as when it floated in water.

$w + s$ is the whole weight of the apparatus when floating in the denser liquid.

The equation $g^1 = \frac{w + s}{v + \frac{1}{4}x\pi z^2}$ is obtained by substituting $g^1$ for $g$, and $w + s$ for $w$ in the equation, $g = \frac{w}{v + \frac{1}{4}x\pi z^2}$, which was given above. Divide by $g = \frac{w}{v + \frac{1}{4}x\pi z^2}$, and there results $\frac{g^1}{g} = \frac{w + s}{w}$, which gives the proportion of the density of the second liquid to the density of water. By subtraction there results $\frac{g^1 - g}{g} = \frac{s}{w}$ and $g^1 - g = \frac{sg}{w}$, that is, the difference between the density of the second liquid, and the density of water is found by multiplying the small weight by 1000 ounces, and dividing this product by the number of ounces, &c., which denote the weight of the aræometer uncharged.

Bead Aræometer.

Small bodies, whose specific gravities are known, serve to indicate the specific gravity of a liquid in which they just remain suspended. In this way, beads of glass, three or four tenths of an inch in diameter, are employed, each of which remains suspended in spirit of a certain specific gravity. The density of each of these beads, or rather bubbles, is regulated by the proportion between the quantity of glass and the cavity which the glass incloses. A piece of bees-wax, whose specific gravity, by the addition of lead, is such, that the body is just suspended in brine of a known density, is used as an aræometer in some salt works. The fresh egg of a common fowl is just sustained by brine of a certain specific gravity, and is employed as an aræometer.

Homberg's.

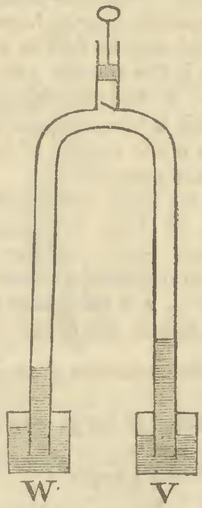
The aræometer of Homberg, consists of a phial, with a slender neck and glass-stopper, so made, that it may be filled with the same volume of different liquids. It is employed in finding the specific gravity of liquids in the following way: 1*st*, The phial is filled with distilled water, and then weighed in a balance; 2*dly*, The phial is emptied, and again filled with the liquid, whose specific gravity is sought, and weighed in a balance, the proportion of the weight of the contents of the phial in the second process to the weight of its contents in the first, is the specific gra-

Aræometer || Araucania.

vity required. The inconveniences which have prevented this method from being generally used, are; the difficulty of completely cleaning the phial from the liquid which it previously contained; the difficulty of filling the phial exactly with the same volume of each liquid; and the variation of the volume of the phial from changes of temperature.

Pump Aræometer.

The pressure of the atmosphere supports columns of different fluids, whose height is inversely as the densities of the fluids. An aræometer has been constructed on this principle. It is a curved tube, one leg of which has its extremity immersed in water, and the other in the spirit whose density is to be tried. On rarifying the air in the tube, by means of a pump fixed at the upper part of the tube, the water ascends in one leg, and the spirit in the other; the height of the column of each liquid being measured by a scale of equal parts applied to each branch of the tube. This instrument has never come into use, probably on account of the difficulty of ascertaining, with precision, the points at which the surfaces of the columns are terminated. See *Encyclopædia*, Art. Hydrodynamics, Part I. ch. 2. sect. 2. for some farther notice of Aræometers. (Y.)




ARAUCANIA, a territory on the western coast of South America, extending 186 miles in length, between the rivers Biobio and Valdivia, and penetrating 420 miles inland to the foot of the Andes. The lower parts of these mountains are included within its limits, and the whole superficies which is bounded by 36° 44′ of south latitude on the north, and 39° 50′ on the south, occupies about 78,120 square miles. Originally, Araucania was of smaller dimensions, not reaching above 300 miles from the sea-shore; but it received a great accession by the union of another territory belonging to the tribe Puelches, in the course of the seventeenth century.

This is a pleasant and fertile country, partly consisting of wide and extensive plains, partly mountainous, with spacious valleys interposed. It contains two considerable lakes, Laquen, called Villarica by the Spaniards, 72 miles in circuit, with a conical islet in the centre; and Nahuelguapi, 80 miles in circuit, which also has an islet towards one side covered with trees. The latter is the source of a river of the same name, which, after a long course, falls into the ocean, near the Straits of Magellan; and the Talton, which discharges itself farther north into the sea, rises from the latter. A great volcanic mountain, fourteen miles in circumference at the base, and visible at the distance of 150, stands near the lake Villarica. Its eruptions are not violent, though it is always in an active state. The summit is covered with snow, but lower down, perpetual verdure is intermixed with woods, and besides mineral springs, several streams flow from it. Sulphur and Salt are plentiful on the eastern confines; and quantities of Ambergrease are thrown up on the coast. Mines of Gold, formerly yielding immense revenues, are said to exist in the southern parts, but ever since the natives expelled their Spanish invaders, they have prohibited resorting to them under pain of death. Possibly all remembrance of their site is lost, and the Araucanians are sufficiently prudent to avoid awakening the cupidity of neighbouring nations by discovering it. This precious metal is not rare beyond their confines. We are acquainted with the vegetable productions of this territory, only in common with those of the surrounding country; they are numerous, useful, and afford a copious supply for the sustenance of mankind. The beauty and utility of a tree called the Pehuen, probably a kind of bread-fruit, or of some analogous species, is particularly celebrated, as uniting the properties of the Pine, Chesnut and Frankincense. It is of spontaneous growth, requiring no culture, and rises 80 feet in height, by about 8 in circumference; the whole tree at full size being of a pyramidal figure. The flowers are conical, and its fruit, which is as large as the human head, is divided into cells, containing kernels resembling chesnuts. These are ate in the same way, or sometimes reduced to flour, and preserved by boiling. A yellowish odoriferous gum exudes through the bark. The sea abounds in fishes, and various phocæ frequent the shores. Of these the sea Elephant is the largest, often being 22 feet in length, and 15 around the breast; it produces more oil than the rest; and is so fat, that undulations under the skin are perceptible during its motion. Furious combats ensue among the males for possession of the females, which latter always retire until their issue; and that for the most part is in the death of one or other of them. Their skins are generally covered with scars; yet notwithstanding the great size of the animal, and its warfare among its own species, a smart blow near the nose is invariably fatal. A species of Hippopotamus is said to inhabit some of the lakes and rivers of Araucania, different from that of Africa, but its existence is not sufficiently authenticated. However, it is only of late years that Naturalists have become acquainted with the real Hippopotamus, whose figure and habits were long considered to be fabulous. One of the most useful animals in this country is the Chilihueque, a species of diminutive camel, greatly resembling the sheep, about 4 feet high, of various colours, grey, brown or black, and bearing very soft wool, which is employed solely in manufacturing the finest cloths. Formerly, it was used as a beast of burden; now it is highly prized by the inhabitants, by whom it is never killed except at festivals, or on occasion of solemn sacrifices.

Inhabitants.

The natives of the country now described, are called Araucans or Araucanians from the province of Arauco, which forms a small portion of it. They denominate themselves *Auca*, which signifies free, or unsubdued, though some European authors have affirmed, that both Auca and Araucanian originated with the Spaniards, as a name of reproach, signifying rebel or savage banditti; and others, such as Falkner, says, that they denominate themselves generally *moluches* or warriors. Whatever may be the truth, they are a

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warlike and independent race, and have shed the blood of their invaders in torrents.

The Araucanians do not differ from the ordinary stature of mankind; their persons are handsome; they are of a strong muscular form and martial appearance; their complexion is of a reddish brown, clearer than that of the other Americans; they have round faces, small expressive eyes, and small flat feet. Deformity among them is very rare. The women are of a fine delicate figure, and many, especially of one of their tribes called Boroanes, are beautiful. The Araucanians possess uncommon vigour of constitution, which is probably augmented by their free and uncontrolled mode of life. Inhabiting a delightful country, and unaccustomed to that variableness of climate which generates lasting distempers, they rarely become grey before attaining sixty or seventy years of age; many are to be seen who have reached an hundred; and to the latest period, their personal and mental faculties remain equally entire.

Their Character.

These people are said to rank high in moral character; they are intrepid and patient of labour, enthusiastic admirers of liberty, which has gained them the name of invincible from their enemies; courteous, and hospitable. But these good qualities are sullied, if not altogether obscured, by numerous vices. They are prone to all kinds of drunkenness and debauchery: they are haughty and presumptuous, entertaining a profound contempt for other nations, and considering war the only genuine source of glory; sentiments which powerfully conspire to keep barbarians barbarous. Not content with exercising their prowess against their neighbours, they practise invasions of each others property, and carry off quantities of spoil. But notwithstanding their natural violence, these private dissensions are generally confined to pillage, without bloodshed, for deadly weapons are seldom resorted to. Their animosity towards the Spaniards being originally roused by just provocation, has remained for centuries unabated; and, in their incursions into their settlements, they have sometimes put all the men to the sword, while the women were spared, and carried into captivity. They have been called faithless and treacherous by that nation; but most probably more from resisting oppression, than from truly meriting such reproaches.

The Araucanians being a military people, have adopted a suitable costume, consisting in clothes fitted close to the body, and a mantle or cloth, called *poncho*, with an opening in the middle, to admit the head. Some of these are of so fine and elegant a texture, as to sell for an hundred, or an hundred and fifty dollars. The head is begirt by a wreath of embroidered wool, and ornamented with beautiful plumes, during warfare. Modesty and simplicity equally distinguish the dress of the women, which is entirely of woollen stuff, and consists of a piece descending to the feet, a girdle, and a cloak, called *ichella*; the hair floats gracefully in tresses over their shoulders, and their heads are decorated with a kind of false emerald, that is held in great estimation. Necklaces and bracelets are also wore for ornament, and rings on every finger. The national colour for all the apparel of both sexes, especially among the lower classes, is greenish blue.

The Araucanians never inhabit towns: their love of independence has deterred them from living in places surrounded by walls, which they consider a mark of servitude: hence they dwell in cottages or hamlets scattered on the banks of rivers, or on plains: and, as their local attachments are strong, each family prefers occupying the same bounds which have served for the subsistence of its forefathers. The houses are simple, kept remarkably clean and neat, and proportioned to the size of the family. They are surrounded by trees, under which they partake of their meals, in the open air during summer; and the wealthy are then fond of displaying their plate. These people are much less carnivorous than most uncivilized tribes, neither do they esteem fish grateful food, and they live chiefly on what is prepared from different kinds of grain. At their feasts, however, or marriages, funerals, and such public occasions, remarkable profusion prevails: three hundred individuals are then sometimes present; the feast lasts two or three days, and as much provision is consumed as would maintain an ordinary family during two years. Fermented liquors form a principal ingredient of the entertainment, and the guests testify great dissatisfaction, should they be at all sparingly supplied with it, whatever may be the quantity of provisions. Every man of property being anxious to entertain his friends, Bacchanalian revels succeed each other, almost without interruption; and they are the chief occupation of the Araucanians, when free of warfare.

Marriage.

Celibacy is thought reproachful here. Both sexes in that state are exposed to contemptuous expressions, and polygamy is practised to an unbounded extent. A man marries as many wives as he can afford to purchase, for the father of each female receives a price on her being transferred to a husband. Marriage is attended with apparent violence. The husband, in concert with the father of his bride, accompanied by some friends, lies in wait near a certain place, where he knows she is to pass. Notwithstanding her shrieks, and affected resistance, she is placed behind him on horseback, and is conducted with much clamour to his house, where her relations receive the covenanted presents, after having partaken of a feast. The expence on such occasions is so considerable, that none except the rich can afford to marry many wives; and the poor are generally content with one or two. The first, however, is alone respected as the real or legitimate spouse; all the others are held in a secondary view; and she has the whole arrangement and regulation of the internal domestic concerns. But it is no easy matter for the husband to repress the jealousy and rivalship excited by the jarring inclinations of his different wives. Each must daily present him with a dish of some food prepared by herself, in her own kitchen or fireplace; for which reason, the Araucanians have a number of fires in their houses equal to that of the women inhabiting them, and the most polite way of inquiring of any one how many wives he has, is asking "how many fires he keeps?" Each wife must, besides, supply her husband with a *poncho* or cloak yearly. They entertain great respect for their husbands; and in addition to their domestic duties,

they have to perform all the most laborious operations. Both sexes practise several daily ablutions, in the course of which they become expert swimmers and divers, and they are able to cross the largest rivers with great facility.

Estimation of Eloquence.

Reading and writing are no part of the accomplishments of the Araucanians, nor can they be induced to acquire either; but they hold oratory in high estimation. Children are accustomed from an early period to speak in public, and are carried by their parents to the national assemblies, where the best Orators of the country display their eloquence; therefore much attention is paid to speaking correctly, and preserving their language pure. So great is their precaution to avoid the introduction of any foreign expressions, that if a stranger settle in their territory, he is compelled to abandon his own name, and assume one in the Araucanian language. The Missionaries who preach in the national language with the design of making converts, are frequently interrupted by the audience when an error escapes them. The speeches of the Araucanian Orators are said to be highly figurative, allegorical, and elevated; they contain all the essential parts of rhetoric, and are constructed by its rules. Their style is impressive, and seems capable of being directed to the passions. They are fond of poetry, which is expressed in blank verse, not in rhyme, and, like that of all barbarous nations, is employed on warlike exploits. Its images are bold, lively, and animated; for it has been truly observed, that unrestrained enthusiasm is the chief characteristic of the poetry of the uncivilized.

Learning.

Their learning, however, is very limited, and certainly the cultivation of poetry will not readily lead to its improvement. In physic, the Araucanians deal in simples, or the practice of ceremonies; and their leading theory ascribes the origin of all diseases to insects or witchcraft. Ordinary remedies are resorted to for destroying the former; but for the latter, a different course is followed. The physician having lighted up the patient's room, desires the women to sing a doleful tune, to the accompaniment of drums, while he fumigates the patient, and a sheep, about to be sacrificed, with tobacco smoke. Having killed the animal, and sucked some blood from its heart, he approaches the patient, pretending to inspect his belly for poison which has been administered by some sorcerer, and then falls into a pretended swoon, accompanied by frightful contorsions. While the sick person's relations question him concerning the cause of the evil, he answers in a manner the most suitable to the occasion, or fixes an accusation on some individual, which frequently leads to the murder of the innocent in revenge of the supposed injury. Their physicians, however, are capable of reducing dislocated joints, and setting fractured bones; they can even perform wonderful cures of wounds, and have a slight skill in dissection.

The Araucanians divide the year into twelve months, the names of which are characterized by their properties, as *Avun-cujen*, the month of fruits; *Cogi-cujen*, the month of harvest; *Huin-cujen*, the unpleasant month; *Hucul-cujen*, the first month of winds; thus somewhat resembling the *Prairial*, *Floreal*, *Nivose*, in the revolutionary language of the French. They divide the day into twelve parts, each equal to two hours with us in duration. The stars are classed in constellations; they are acquainted with the planets; and some among them even entertain speculations of their being other inhabited worlds. Comets are supposed to originate in terrestrial exhalations united in the higher regions; and they call eclipses the death of the sun or moon. Few generations can avail themselves of the knowledge of their ancestors, or preserve their own to posterity, where writing is not practised.

They have little acquaintance with the arts, and are ignorant of the principles of commerce: chiefly employed in warfare, they are accustomed to constant privations, and thence abstain from those luxuries which are the offspring of a state of peace and the arts. Their principal manufacture consists of *ponchos* or Indian cloaks, which some years ago they were wont to dispose of to the extent of 4000 annually, either to the neighbouring tribes or to the Spaniards: their other articles of traffic are cattle, horses, feathers, and baskets of curious workmanship. They have the character of strict integrity in commercial transactions, which are conducted entirely by barter. They have no money, and for their own commodities receive wine, iron, and hardware.

Government.

The government of the Araucanians bears some analogy to the feudal system, but it does not appear, that, as in Europe, their lands are held by military tenure. The whole territory is divided into four parallel districts called *Uthal-mapus*, being the maritime country, the plains, the country at the foot of the Andes, and that which is occupied by part of these mountains. Each district is subdivided into five provinces, and each province contains nine counties; therefore their total possessions are partitioned into an hundred and eighty parts. Each *Uthal-mapu* is governed by a chief, styled *Toqui* or commander, subordinate to whom are the *Apo-Ulmenes*, and on these, in so far as respects military affairs, are dependent, the *Ulmenes*, under whose immediate jurisdiction the counties are placed. All these orders have badges of distinction; the *Toqui* a stone hatchet, the *Apo-Ulmen* a silver-headed baton, encircled by a ring on the middle, the *Ulmen* a baton simply with a silver head, and their dignities are hereditary. The whole combine in a great national council usually held in a plain, where the pleasures of the table usually divide their attention with state affairs. This grand council is vested with the power of declaring war; and the election of a military commander in chief, immediatly follows a resolution to that effect. Should none of the *Toquis* be themselves qualified for so important a station, any other person whatever may be chosen, even one of low rank: and on his appointment he assumes the title of *Toqui*, bears the stone hatchet, which is laid aside by the rest, who now take an oath of fealty to him. He regulates the number of soldiers to be furnished by each portion of the state, and nominates the higher officers, who have the choice of their own subalterns.

Warfare.

Meantime expresses are secretly dispatched to all the allies of the nation, announcing the approach of hostilities: which are intimated by investing the envoy with a bundle of

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arrows tied together with a red string; but if they have actually commenced, the finger of a slain enemy is added to the arrows. The armies consist of five or six thousand men, cavalry and infantry, though some authors who have written on this subject, deny that the whole country can produce such a force: the infantry is divided into regiments, of 1000 each, containing ten companies of 100 men: the cavalry is divided in the same manner, but the numbers are not always alike: their arms are swords and lances; those of the infantry, pikes or clubs pointed with iron. The onset of these troops is terrible; they bear every thing before them, and always try to cope hand to hand with their foes. Each soldier, as was the custom of Europe in feudal times, carries his own provisions, which consist only of a small bag of parched meal; and this diluted with a little water, generally proves sufficient subsistence until reaching an enemy's country, where he can live at free quarters. Their conflicts are conducted with great desperation, though, at the same time, wonderful regularity and subordination are preserved: but as all pant after military glory, and as valour is the only path to fame, the post of honour is eagerly courted, where rank after rank is successively destroyed before defeat or victory can be declared. The battle over, and the spoils of war divided by equal portions, according to numbers, not in proportion to rank, the next ceremony is a horrible sacrifice of one of the unfortunate captives to the manes of those who have fallen, called *Proluncon*, or the dance of the dead. Many barbarous nations, nay some emerging from the darkness of their savage state, have been accustomed to offer up human sacrifices; and all mankind have believed, at one period or other in their progress to civilization, that blood was grateful to their Deities, or that it was necessary for the repose of their deceased relatives. Some, less cruel and sanguinary, have been content with the destruction of the lower animals; but others, more atrocious, have shed the blood of their own species. This deliberate murder has been of three distinct descriptions: first, to propitiate Divinities, or to avert their wrath; secondly, that the victims might be useful to deceased persons passing to a future state; and thirdly, that the manes of those who had fallen in war might be appeased. The *Proluncon*, nevertheless, is seldom resorted to; but, when determined on, it is conducted with great formality. The miserable prisoner is seated on a horse, deprived of its ears and tail, with his face turned towards his own country, and ignominiously conducted amidst a circle of the Araucanians and their chiefs. There he is obliged to dig a hole in the ground, wherein a number of rods are cast in succession; and while he repeats the names of the warriors of his nation, the surrounding soldiers accompany his words with contempt and execrations. He is next ordered to cover the hole, as if to bury the reputation and value of his fellow warriors, whom he has just named. Then the *Toqui*, or one of his bravest companions, ambitious of the honour, dashes out the brains of the unfortunate victim with a club. But the solemnity is not yet completed; for, with cannibal-like ferocity, his heart is instantly torn out, and presented to the Chief, who, sucking a little of the blood, transmits it to his officers, to follow his example. Should the skull of the prisoner not have been fractured by the violence of the blow, a cup is made of it, which, as is told of the ancient Scythians, is used at the succeeding banquets. Meanwhile the soldiers strip the flesh from off the bones, in order to procure them for flutes; and, having cut off the head, carry it on a pike around their circle, stamping a measured march, and vociferating the war song of Savages. In the next place, the head of a sheep is applied to the mangled corpse, and the whole ceremony closes with a scene of riot and intoxication. Should a truce follow victory or defeat, and both, or either side be weary of the contest, the parties meet in congress, and an Araucanian Orator makes a speech on the evils of war, the advantages of peace, and the most eligible means of mutually preserving it. A branch of the cinnamon-tree is here a pacific emblem, as that of the olive is elsewhere. If the enemies are Spaniards, their President or leader makes an answer adapted to the circumstances of the case; and articles of treaty having been agreed upon, several *chilihueques* are sacrificed for its permanence. The Chiefs of each party then participate of a meal together, and presents are distributed to those of the Araucanians. It is affirmed, that, as the latter suffer least from warfare, and conduct it without much difficulty, they never sue for peace, and thence that the first overtures always proceed from the Spaniards, with whom they have incessantly been engaged in bloody and destructive contests. But it is rather to be inferred, from the best authorities, that they have not invariably felt equal confidence; and that their numbers, at the end of a war, have been so greatly diminished, as to make them as desirous as their foes of pacification. A congress must frequently be repeated, as without it, the Araucanians, a haughty race, would consider themselves neglected and despised, and go to war for no other reason.

Laws.

The civil code of these people is very limited, and, as well as their criminal laws, rest entirely on consuetudinary principles, none being written. The latter chiefly respect the punishment of murder, robbery, witchcraft, adultery, and treachery, which are all capital offences. The murderer, however, can escape by a pecuniary composition with the relatives of the deceased; and husbands and fathers are not subject to any punishment for putting their wives or children to death, because they are judged to be the natural masters of their lives. Persons accused of sorcery are first tortured by fire, on purpose to obtain a discovery of their accomplices, and then stabbed with daggers. Execution immediately follows the sentence, and justice is sometimes administered in a very irregular and tumultuous manner. Impatient of delay, the Araucanians often resort to the law of retaliation in lesser offences, which leads to the subversion of all public order, and is the source of many enormities in their turn becoming the objects of this kind of retributive justice.

Religion.

The religion of the Araucanians is a compound of absurdity invented by the designing or superstitious, and imposed on the blind and credulous whom they found ready to receive it; but, amidst that absurdity, containing some principles which have generally

Araucania. been admitted by the more reflecting part of mankind. They are said to believe in a Supreme Being, who has subordinate Deities, like their own subaltern officers. One of these is the god of war, another a benevolent, and a third a malevolent divinity, who is called *Guecubu*. This last is the most active agent of all others, and the source of every misfortune. If a horse dies, it is because the *Guecubu* has rode him; if the earth trembles, it is because the *Guecubu* has given it a shock; nor does a person ever die, who is not suffocated by the *Guecubu*. Such is the language of the Missionaries, from whom alone our principal knowledge of the Araucanians is derived. However, these Divinities receive no adoration; they have no temples, and only on occasion of some severe calamity, or the conclusion of a peace, are sacrifices offered to them. Then the Araucanians immolate animals, and burn tobacco, which is esteemed the most grateful incense. The Supreme Being, and the benevolent Deity, are invoked on urgent occasions,—those which most naturally induce mankind to seek the protection of superior powers. Christianity has never made any progress among this nation; and although the Missionaries are well treated, respected, and allowed ample liberty to preach their doctrines, they are utterly unsuccessful in making converts. The Araucanians are extremely superstitious; they have implicit confidence in omens and divination, particularly such as may be gathered from dreams, or the flight of birds; and he who has confronted death with intrepidity in battle, will tremble at the sight of an owl. They entertain uncommon apprehensions of pretended sorcerers, who they imagine keep under control a kind of beings partaking of the nature of men and animals, concealed in caverns by day, but let loose to transform themselves into nocturnal birds, that shoot invisible arrows at their enemies as they traverse the air. On all occasions they consult Soothsayers, who boast of their own powers, and give firm credit to their predictions. The immortality of the soul is a principle admitted by the Araucanians; they maintain that the human frame is compounded of two substances essentially different, one destructible on death, the other incorruptible and incorporeal, which exists for ever. They have also wavering ideas about a place of future reward and punishment, situated to the west beyond the sea; but regarding the actual state of the virtuous or the vicious, they are not agreed. Their funerals are ceremoniously conducted. The body of the deceased, clothed in his best attire, is laid on a high bier or scaffold, where it remains during the night, and the interval is passed by the relatives in weeping, or in eating with those who come to offer consolation. This meeting is called *caricahuin*, or the black entertainment. On approaching the place of interment, a woman walks behind strewing ashes on the way, to prevent the soul, it is supposed, from returning to its late abode; and the body being laid on the ground, is surrounded with arms and other instruments, and covered with a pyramid of earth or stones. Sometimes a horse is killed and inclosed among them. But no sooner do the relatives retire, than, according to their ideas, an old woman comes in the shape of a whale, to transport the deceased to the Elysian fields, though before his arrival, a toll is exacted by another old woman guarding a very narrow passage, who malevolently deprives the passenger of an eye, in event of refusal. In this Elysium the same functions are exercised by the souls of the deceased as on earth; husbands have the same wives, but the latter have no children, because that region cannot be inhabited by any but the spirits of the departed. They may revisit their own country, still possessing the same properties as when united to the body; and the Araucanians conceive that the tempests of wind, or thunder and lightning which they witness, originate from their furious combats in the air. A storm never happens among the Andes, or on the ocean, which they do not ascribe to a battle between the souls of their deceased countrymen, and those of the Spaniards; the roaring of the wind is the trampling of their horses; thunder the rolling of drums; and lightning the flashes of their artillery. If the course of the storm travels towards the Spanish frontier, they believe that the spirits of their countrymen are victorious; if it approaches their own territory, they are overwhelmed with consternation, and encourage them to be firm and resist their enemies.

Though the Araucanians wander about their own country, they are rarely seen out of it, unless while waging war; sometimes they cross to the eastern parts of South America, and, meeting with another tribe called Pampas, repair to Buenos-Ayres, there passing for the people of that nation.

History. Our knowledge of their history is limited nearly to the period when the American Continent was visited by Europeans in the fifteenth century; and as they are themselves destitute of written records, it must be sought among the Spanish Chronologers. About the year 1450, an Inca of Peru attempted the conquest of the extensive region of Chili, and consequently, of Araucania along with it; but his army retired on being defeated in a sanguinary engagement. A century later the Spaniards having gained a firm establishment in America, resolved to extend their conquests, but were obstinately opposed by the Araucanians with a body of 4000 men, led beyond their own confines; and their conduct on this occasion, though they did not prove victorious, impressed their enemies with apprehensions which have never abated. The Spaniards were at length enabled to form settlements within their boundaries; and sometime after, Pedro de Valdivia, a celebrated officer, was defeated in a pitched battle, taken prisoner, and dispatched with the blow of a club, about the close of the year 1553. A period of bloody warfare followed, which cost the Araucanians the life of their favourite commander Lautaro, whose talents were held in the highest esteem. Though sufficiently exasperated before, their resentment was inflamed still farther against the Spaniards for their barbarous mutilation of those unfortunate prisoners who fell into their hands. One of their bravest commanders Caupolican, being treacherously betrayed after a gallant resistance, was condemned to be impaled alive, and shot with arrows; but when brought to the place of punishment, and beholding the ignominy that awaited him, he hurled the executioner from the scaffold, exclaiming, "Is there no sword,

Araucania. and some less cowardly hand to be found to put to death a man like myself? This has nothing of justice in it,—it is base revenge." But the merciless Spaniards were deaf to his appeal. Various successes and discomfitures ensued, when, about the termination of the sixteenth century, the Araucanians besieged the enemy in the fortress of Puren. Unable to reduce the place so speedily as he desired, their chief presented himself before it, mounted on a fine horse recently taken from the governor, and challenged the Commander, Don Garcia Ramon, to single combat at the end of three days. The defiance being accepted, the Chieftains met, each accompanied by a small body of men who stood at a distance. Putting spurs to their horses, they advanced impetuously, but at the first encounter the Araucanian *Toqui* was pierced through the body by his adversary's lance. Refusing to acknowledge himself vanquished, he endeavoured to remount his horse, but in doing so expired. These events were followed by the siege of Villarica, a rich and populous city belonging to the Spaniards, which, after a resistance of two years and eleven months, fell into the hands of the Araucanians. A similar fate awaited Imperial and Osorno, other cities of equal importance, and their inhabitants were led into captivity. Incessant wars, with very short intervals of repose, occupied almost the whole of the seventeenth century, and thousands after thousands fell in their prosecution. But the Araucanians received an important accession to their strength, in the union of a warlike tribe called Puelches, which was thenceforth incorporated under the same government. The eighteenth century did not open more auspiciously; for although a cessation of hostilities had prevailed some time, the Araucanians became sensible that it afforded opportunities for the Spaniards to form new and permanent establishments within their territories: the arrogance of those who resided among them, under pretence of protecting the missionaries, had also excited their indignation. Villumilla, a man of low origin but distinguished abilities, was appointed military *Toqui*, or commander in chief, and formed a plan for expelling the Spaniards from the whole coast. But his attempt to raise his own and the neighbouring countries, in the year 1723, proved abortive, and the war was marked by nothing except some inconsiderable skirmishes. Peace having been restored, the Spanish governor conceived a scheme for the civilization of the Araucanians (regarded as chimerical by those best acquainted with their disposition), which was persuading them to live in cities. They agreed, however, to build a city, and were supplied with materials by the Spaniards, who also had assistants and superintendents on the spot, but suddenly seizing their arms, they killed their overseers, about the year 1753. Peace was once more interrupted by repeated encounters, and at length a bloody battle ensued in the year 1773. The Spaniards found themselves unable to retain any settlements within the Araucanians' territories, and the natives, in opposition to all the skill and force employed against them, have ever since been able to keep possession of their country. See the excellent work of Molina, on the *Natural and Civil History of Chili*, and Alcedo's *Geographical and Historical Dictionary*, Art. Chili. (s.)

Arcon. ARCON (J. C. E. Le Michaud D'), a French engineer and military writer of eminence, and memorable as the inventor of the *Floating Batteries* employed against Gibraltar, was born at Pontarlier in the year 1733. He was originally destined for the church; but, instead of employing himself in the studies suited to that profession, he became wholly engrossed with plans of fortifications, and was at length admitted, with the consent of his parents, into the Corps of Engineers. He distinguished himself at several sieges during the seven years' war; and had acquired so much reputation by his professional services and by his writings, that he was specially employed to assist in the last grand effort made by France and Spain for the reduction of Gibraltar, in 1782. It was about this period that he projected the famous floating batteries; an invention which inspired the combined armies with the greatest hopes of success, and which at first occasioned no small degree of alarm in the British garrison. "The battering ships," says Drinkwater, in his interesting account of this memorable siege, "were found to be no less formidable than they had been represented. Our heaviest shells often rebounded from their tops, whilst the 32 pound shot seemed incapable of making any visible impression upon their hulls. Frequently we flattered ourselves they were on fire; but no sooner did the smoke appear, than, with the most persevering intrepidity, men were observed applying water, from their engines within, to those places whence the smoke issued." Of the ultimate fate of these expensive and formidable engines of attack, all British readers must be sufficiently informed. Not one of the whole ten escaped destruction from the bombs and red-hot balls poured upon them from the garrison. M. D'Arcon, however, published a memoir to show, that his batteries were wilfully exposed to destruction through the envy and jealousy which the contrivance had excited among the Spaniards; and this statement seems to have obtained the general concurrence of his countrymen. But projectors do not readily admit any inadequacy in their schemes; nor will a vain-glorious people, who have been foiled in war, ever ascribe their disgrace to the superior skill or constancy of their enemy.

M. D'Arcon appears in the capacity of a General in the first years of the Revolution; and, in particular, was employed in the invasion of Holland, where, in 1793, he besieged and took several fortified places. He soon afterwards withdrew, or was driven from public life; and remained in retirement till 1799, when he was made a member of the Conservative Senate by Bonaparte. He died the following year, aged sixty-seven. He was a member of the Institute, and author of the following works:—1. *Reflexions d'un Ingenieur, en reponse à un Tactitien*, 1773, in 12mo. 2. *Correspondance sur l'Art de la Guerre, entre un Colonel de Dragons et un Capitaine d'Infantrie*, 1774, in 8vo. 3. *Defense d'un Systême de Guerre Naturale*, &c. 1779, in 8vo. 4. *Mémoires pour servir à l'Histoire du Siege de Gibraltar*, 1783, in 8vo. 5. *Considerations sur l'Influence du Genie de Vauban dans la Balance des Forces de l'Etat*, 1786, in 8vo. 6. *Examen detaillé de l'Importante Question de l'Utilité des*

Arcy ‖ Argyleshire.

*Places Fortes, et Retranchements*, 1789, in 8vo. 7. *De la Force Militaire Considerée dans ces Rapports Conservateurs*, 1790, in 8vo. 8. *Considerations Militaires et Politiques sur les Fortifications*, 1795, in 8vo. This work was published at the expence of the Government, and contains a sort of digest of all his observations and opinions on military subjects. —See *Biographie Moderne*, Tom. I. and *Biographie Universelle*, Tom. II.

ARCY (Patrick D'), Member of the Academy of Sciences of Paris, a general officer in the French army, Chevalier of the order of St Louis, &c. was born in Ireland in 1725. His parents, in consequence of their attachment to the House of Stuart, left Ireland, and settled in France. He studied Mathematics with distinguished success under Clairaut the elder, and had for his fellow-student the celebrated Clairaut the son. He obtained a commission in the French army; and, in 1746, was embarked in the expedition which was intended to make a descent in Scotland. He was made prisoner, and was treated like other prisoners of war, no notice being taken of his having been born a British subject. He continued attached to the House of Stuart during the whole of his life.

In 1760, he published his *Essay on Artillery*. To estimate the force of the explosion of gun-powder, he employed a cannon suspended, so that the arc of vibration described by it on its being fired, was a measure of the force of explosion. To measure the initial velocity of a projectile, he used Robins's machine. Robins showed, that when the velocity of a projectile is great, the resistance opposed by the air is not in proportion to the square of the velocity, as is the case when the velocity is small. D'Arcy made experiments with a view of ascertaining this law, but without success. His work contains an account of experiments made by him to determine the most advantageous length of cannon. He published a paper on hydraulic machines in 1754, where he treats of the maximum of effect of water-wheels. He also published a paper concerning the duration of the impression of light on the retina. He found that the revolution of a luminous point must be rapid, so as to be performed in $\frac{8}{60}$ of a second at the least, in order to produce the appearance of a continued luminous circle.

He was of a handsome figure, and passed much of his time in the gay world. A short time before his death he married a young lady his niece, and took the title of Count. Although attached to the House of Stuart, and therefore inimical to the English Government, yet he admired the national character of the English, and was attentive to English travellers. He died in 1779, and was succeeded at the Academy by the Abbé Bossut. (Y.)

Mainland.

ARGYLESHIRE, or Argyllshire, an extensive County in the west of Scotland, is usually described under two great divisions,—the mainland, and such of the Western Islands as are politically attached to it. It is of the former only, that we propose to give some account at present, referring to the article Hebrides for the Islands noted below,* which form a part of this County.

Situation.

The mainland of Argyleshire, situate between 55° 21′ and 57° north latitude, and between 1° 22′ and 3° 25′ of longitude west from Edinburgh, is bounded by Inverness-shire on the north, by the Shires of Perth and Dumbarton on the east, by the Irish Sea on the south, and by the Atlantic Ocean on the west; the Firth of Clyde, which separates it from the Shire of Renfrew, forming its boundary on the south-east. Its greatest length, from the Mull of Kintyre on the south, to the point of Ardnamurchan on the north, is 115 miles; its breadth above 68; and from the windings of the numerous bays and creeks with which the land is everywhere indented, it is supposed to have more than 600 miles of sea-coast. Of 27 parishes into which the mainland of Argyleshire is divided, two of which belong in part to Inverness-shire, only one is altogether inland. The extent of this part of the County, of which the land comprehends 2200 square miles, and the lakes 60, is equal to about one-thirteenth part of the whole of Scotland.—Having pointed out the principal divisions, and given a general view of the surface in the article in the body of the work, we shall here confine our notices to the industry and condition of its inhabitants.

Extent.

Agriculture.

The only crops cultivated to any extent on the mainland of Argyleshire, are bear or bigg, oats, and potatoes. A little wheat is raised near Campbelltown, and in other parts of Kintyre; and a few patches of turnips are occasionally seen, but chiefly on the farms of proprietors. Clovers also, though more frequent, have not yet come into extensive culture, notwithstanding these, and other green crops, are better adapted, both to the climate and the leading branches of the husbandry of the country, than grain. The principal object in the culture of bigg is the supply of the distilleries. The great body of the inhabitants live almost exclusively on oatmeal and potatoes; of the former of which they have been in the practice of importing about 20,000 bolls (of 140 lbs.) annually. Considerable progress, indeed, has been made of late in the improvement of agriculture, but this is necessarily limited by the small proportion of land fit for profitable cultivation; there being only 125,000 acres arable out of 1,408,000 which this part of Argyleshire contains; as well as by the mode in which, till very lately, farms were held—without leases—and for performance of many vexatious services. Even, at this time, we can recognise in Argyleshire the prominent features of the feudal ages,—a few great proprietors, and a numerous tenantry, indolent and poor. Of the valued rent, taken in 1751, of the mainland, with four small Islands, amounting to L.9924, 8s. 1d., almost a fourth belongs to two pro-

Valued Rent.

* Those of the first rate are Islay, Mull, and Jura; of the second,—Gigha, and Cara, Colonsay, Lismore, Tyree, Coll, Ulva and Gometra, Kerreray, Luing, Seil or Saoil; and of the third,—Scarba, Lunga, Shuna, Icolmkill or Iona, Eisdale, Inch Kenneth, Staffa, Monk, Rum, and Cannay.

Argyleshire. proprietors. This valuation was considered to be equal to the half of the real rent at that period, after deducting all public burdens; but in 1798, when the agricultural survey of the County was published, the gross rental had risen to L. 89,000, collected from upwards of 2700 tenants; and in 1811 the rent of the whole County, of which the Islands might produce about a fifth, amounted to L.192,073, 14s. 2d. for the lands, and for the houses to L.5208, 18s. 10d. The frequent transference of landed property, which has taken place in this County within the last fifty years, and the example and encouragement of the Duke of Argyle, the greatest landholder in it, cannot fail to extend a more beneficial system of rural economy.

Real Rent.

Cattle.

Cattle were long the principal source of the revenue of the landholders and tenantry of Argyleshire; and the native breed, which has been improved of late by more careful treatment, is well known to be equal, if not superior, to any other race of cattle in the kingdom. Their number in 1798 was computed at upwards of 50,000, and they are understood to have increased since; for though they are now excluded from the more elevated tracts, which are more profitably occupied by sheep, the improved management of the lower grounds has, upon the whole, enlarged the means of their subsistence. These cattle are sent from the country in a store condition, commonly when about three years old, and fatted on the pastures of the south, the greater number for the consumption of England. The dairy begins to be an object of attention in the peninsula of Kintyre, where there is a large proportion of arable land, but cannot be extended to the inland and more mountainous districts of the county.

Sheep.

Until the middle of last century, the only sheep in Argyleshire (and their number was inconsiderable), were of the small native race, the same that are still to be found in the Hebrides, and in most parts of the Highlands of Scotland and of Wales. About that period coarse woolled heath sheep were introduced into the higher and more barren districts; and as it was soon discovered that the scanty herbage of these gloomy mountains, could be converted into a much greater quantity of mutton than of beef, besides yielding a valuable article of manufacture,—these hardy animals soon spread over extensive regions, upon which cattle could barely subsist in the summer months: and the income of the landed proprietors, and of the public, was accordingly augmented in proportion. Notwithstanding the outcry of ignorance, and the more mischievous speculations of mistaken philanthropy, the introduction of this species of live stock, now increased to about 300,000, has not, as we shall see immediately, had the effect of diminishing the population of Argyleshire.

Woods and Plantations.

In this division of the County, there is a considerable extent of natural coppice woods; probably near 40,000 acres, which are cut periodically, commonly every 19 or 20 years, and are understood to return about 20s. per acre annually. Very extensive plantations have been formed by the Duke of Argyle and other proprietors. About 20 years ago, those of his Grace were reckoned to contain 2,000,000 of trees, then worth 4s. each, amounting to the enormous sum of L. 400,000.

Fisheries.

Next in importance to its agriculture, are the fisheries, which, from the great extent of sea coast, and the form of the district, penetrated in almost every direction by arms of the sea, and traversed by extensive lakes, ought to furnish food and employment to the inhabitants, to an extent, perhaps, still greater than their barren territory and ungenial climate can supply. Some notion of their great importance may be formed, when we are told that the herrings caught in Lochfine alone, in the years 1794 and 1795, were computed to be worth more than L. 80,000 (Smith's *Survey*, 1798). But the regulations of the revenue laws in regard to salt are universally complained of, as an intolerable grievance; forming an insuperable obstruction to the industry of the lower classes, who have not the means, nor even the knowledge, which a strict compliance with these regulations requires. Whole cargoes of herrings have been thrown into the sea in a putrid state, and others used as manure, in consequence of the inability of the fishermen to find surety for the requisite supply of salt, according to law.

Mineralogy.

The mainland of Argyleshire is principally composed of primitive rocks, which, in some quarters, are skirted and intermixed with those of the transition class; while flœtz rocks occur very sparingly. No volcanic rocks have hitherto been met with in the mainland of Argyleshire, but those of an alluvial nature abound everywhere. The primitive and transition rocks are stratified, and the general direction of the strata is from NE. to SW. The primitive rocks are granite, gneiss, mica slate, clay slate, limestone, porphyry, sienite, trap, and quartz rock. The transition rocks are greywacke, greywacke slate, clay slate, trap, and quartz; and the flœtz rocks are red sandstone, conglomerate, and rocks of the coal formation. The Islands off the coast of Argyleshire afford highly interesting examples of rocks of the different classes; Isla and Jura of the primitive and transition rocks; Mull of flœtz and primitive rocks; Staffa, Rum, and Cannay, of flœtz rocks; and Coll, Tyree, and Iona, of primitive rocks.

Coal has been wrought for many years near Campbelltown in Kintyre, and lead at Strontian in Sunart; and besides the slate quarries of Eisdale, an Island belonging to this County, others have been opened at Ballachelish in Appin.

Manufactures.

Manufactures have made little progress in this district, and no attempts to establish them upon a large scale have yet been successful. Mr Dale endeavoured to extend to it some branches of the cotton manufacture, which failed, it is said, from want of water carriage; but a number of weavers in Campbelltown and its neighbourhood, have been employed for some time in working cottons from Glasgow. The late Duke of Argyle, almost 40 years ago, set on foot a woollen manufactory near Inverary, which, notwithstanding very uncommon encouragement given to it by his Grace and the other landed proprietors, has been long in rather a languishing state. There is a bleachfield in Kintyre; tanneries at Campbelltown and Oban; iron works in Upper Lorn and at Loch-

Argyleshire. fine, below Inverary, belonging to English companies, who bring the ore thither, chiefly for the sake of the charcoal which the woods afford; and near Campbelltown, the formation of salt from sea water has been lately carried on to some extent. The manufacture of kelp from sea weed, to the extent of 600 tons annually, is none of the least profitable branches of industry; and that of their scanty crops of grain into ardent spirits, certainly the most pernicious.

Commerce. The commerce of Argyleshire is also very limited, its exports consisting chiefly of raw produce; sheep and cattle, and fish, form at least two thirds of the whole: The imports are almost confined to the supply of necessaries, including only such articles of luxury, as habit has rendered scarcely less indispensable.

But, though such is the present state of this extensive territory, there is reason to anticipate a great increase of its wealth, of its industry, and of its population, as soon as a revisal of the revenue laws shall have removed the present obstacles to the prosecution of the fisheries. It is upon this species of industry, that the prosperity of the County must be founded; and it is only after wealth has flowed in from this source, that the inhabitants can be expected to succeed in manufactures or in commerce. To its natural advantages, a very important addition has been made by the Crinan Canal, cut across the peninsula of Kintyre, at an expence of L. 140,000; which shortens the voyage from the West Highland and Hebridian ports, to the river Clyde, about 200 miles. The Caledonian Canal, from the access it will give the County to the German Ocean, and still more, from the frequent intercourse of which it will be the channel, must contribute, in an eminent degree, to the prosperity of Argyleshire. Canals.

The population of the whole County, as taken under the Acts 1800 and 1811, will be seen from the following Tables: Population.

1800.

| DISTRICTS. | HOUSES. | | | OCCUPATIONS. | | | PERSONS. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Inhabited. | By how many Families occupied. | Uninhabited. | *Persons* chiefly employed in Agriculture. | *Persons* chiefly employed in Trade, Manufactures, or Handicraft. | All other *Persons* not comprised in the two preceding classes. | Males. | Females. | Total of Persons. |
| Argyle | 2578 | 2827 | 4 | 3494 | 671 | 9087 | 6764 | 7384 | 14,148 |
| Cowal | 1259 | 1380 | 13 | 901 | 415 | 5268 | 3064 | 3470 | 6534 |
| Islay | 2370 | 2393 | 1 | 3309 | 754 | 6253 | 6045 | 6727 | 12,772 |
| Kintyre | 2884 | 3496 | 8 | 4252 | 1079 | 11,105 | 7706 | 9007 | 16,713 |
| Lorn | 2439 | 2581 | 4 | 5254 | 808 | 7020 | 6146 | 6936 | 13,082 |
| Mull | 1579 | 1601 | 2 | 1868 | 468 | 5151 | 4042 | 4568 | 8610 |
| * | 13,109 | 14,278 | 32 | 19,078 | 4195 | 43,884 | 33,767 | 38,092 | 71,859 |

1811.

| DISTRICTS. | HOUSES. | | | OCCUPATIONS. | | | PERSONS. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Inhabited. | By how many Families occupied. | Building and uninhabited. | *Families* chiefly employed in Agriculture. | *Families* chiefly employed in Trade, Manufactures, or Handicraft. | All other *Families* not comprised in the two preceding classes. | Males. | Females. | Total of Persons. |
| Argyle | 2702 | 3720 | 76 | 1568 | 545 | 1607 | 7729 | 7908 | 15,637 |
| Cowal | 1212 | 1276 | 44 | 789 | 329 | 158 | 3318 | 3569 | 6887 |
| Islay | 2636 | 2687 | 1162 | 1284 | 615 | 788 | 6814 | 7348 | 14,162 |
| Kintyre | 2959 | 3733 | 62 | 1074 | 924 | 1735 | 8404 | 9882 | 18,286 |
| Lorn | 2721 | 2845 | 353 | 1064 | 752 | 1029 | 6462 | 7317 | 13,779 |
| Mull | 3010 | 3107 | 24 | 2642 | 254 | 211 | 7948 | 8886 | 16,834 |
| | 15,240 | 17,368 | 1721 | 8421 | 3419 | 5528 | 40,675 | 44,910 | 85,585 |

* No returns for Kilfinichen and Kilvicuen; population in 1791, 3002
Tyree, population in 1792, - - 2416
Rum, Cannay, and Muck, population in 1795, - 940

6358

The whole population in 1800 must therefore have amounted to 78,217. (A.)

# ARITHMETIC.

Introduction.

The *Encyclopædia* contains a short treatise of Arithmetic, constructed in the ordinary way. But a philosophical exposition of the principles of numerical calculation has long been a desideratum in our systems of elementary instruction. The operations of Arithmetic, from being so common, are apt to be reckoned vulgar, and hence abandoned to the blind and mechanical application of certain rules. Yet the study of numbers, if rightly directed, is admirably fitted for opening the mind, and training it to habits of accurate thought, which are of such vast importance to the pupil, whether he means afterwards to engage in the details of business, or aspires to the ulterior pursuits of science. But the theory of numeration acquires a higher interest, from its being closely interwoven with the texture of human society. The diligent inquirer may trace, in the obscure vestiges of ancient language and practice relative to numbers, the slow progress of the mind, from the first dawnings of reason to the full illumination of day. What a vast interval, in the range of intellectual achievement, from the knots or shells which the ferocious savage employs in reckoning his prisoners, to that magic play of figures by which the astronomer, instructed in all the refinements of calculation, and aided by the sublime invention of logarithms, penetrates through time and space, and determines with unerring certainty the changes of the heavens in future ages!

We purpose, therefore, in this article, to give a philosophical view of the Elements of Arithmetic. But our object is, only to sketch the great outlines of the science, without descending to all the subordinate or practical details. The exposition of those principles in a simple form may proceed with ease, and will derive additional interest from the variety and importance of the collateral discussions which it involves. We shall endeavour to elucidate the origin of numbers, to trace their early application, and to connect the progress of arithmetical computation with the history of civil society. But to succeed in the performance of this task, it would require much patient and laborious research in quarters which have hitherto remained almost unexplored. Where so many difficulties must be surmounted, the first attempt will need some portion of indulgence. We shall endeavour to maintain perspicuity, though at the risk of appearing tedious. But while intently pursuing the chief object, we may sometimes fail in observing the due proportions in the distribution of the subordinate parts of the discourse.

Arithmetic may be viewed under two very distinct forms, that would require separate appellations. 1. *Palpable Arithmetic*, in which numbers are exhibited by counters, or abbreviated representatives of the objects themselves; and, 2. *Figurate Arithmetic*, in which numbers are denoted by help of certain symbols, or artificial characters, disposed after a particular order. The progress of Arithmetic is analogous to that of writing, but it has followed the advances and transitions of this sublime art at a great distance. The numeration by counters, balls, or strokes, evidently resembles hieroglyphics or picture-writing; while the invention of the alphabet, so happily contrived for the rapid transmission of thought, probably led the way to the subsequent discovery of the science of *Figurate Arithmetic*, founded nearly on similar principles. These capital divisions of Arithmetic we shall consider in succession.

Introduction.

## PALPABLE ARITHMETIC.

The idea of number, though not the most easily acquired, remounts to the earliest epochs of society, and must be nearly coëval with the formation of language. The very savage, who draws from the exercise of fishing or hunting a precarious support for himself and family, is eager, on his return home, to count over the produce of his toilsome exertions. But the leader of a troop is obliged to carry farther his skill in numeration. The systematic practice of war and murder has ever distinguished our species from other animals of prey. The chieftain who prepares to attack a rival tribe, marshals his followers; and, after the bloody conflict has terminated, he reckons up the slain, and marks his unhappy and devoted captives. If those numbers were small, they could easily be represented by very portable emblems, by round pebbles, by dwarf-shells, by fine nuts, by hard grains, by small beans, or by knots tied on a string. But to express the larger numbers, it became necessary, for the sake of distinctness, to place those little objects or counters in regular rows, which the eye could comprehend at a single glance; as, in the telling of money, it would soon have become customary to dispose the rude counters, in two, three, four, or more ranks, as circumstances might suggest. The attention would then be less distracted, resting chiefly on the number of marks presented by each separate row.

Language insensibly moulds itself to our wants. But it was impossible to furnish a name for each particular number: No invention could supply such a multitude of words as would be necessary, and no memory could ever retain them. The only practical mode of proceeding was to have recourse, as on other occasions, to the powers of classification. By conceiving the individuals of a mass to be distributed into successive ranks and divisions, a few component terms might be made sufficient to express the whole. We may discern around us traces, accordingly, of the progress of numeration, through all its gradations.

The earliest and simplest mode of reckoning was by *pairs*, arising naturally from the circumstance of both hands being employed for the sake of expedition. It is now familiar among sportsmen, who use the names of *brace* and *couple*, words that signify *pairing* or *yoking*.—To count by *threes* was another step, though not practised to the same extent. It has been preserved, how-

ever, by the same class of men, under the term *leash*, meaning the strings by which *three* dogs and no more can be held at once in the hand.—The numbering by *fours* has had a more extensive application: It was evidently suggested by the custom, in rapid tale, of taking a pair in each hand. Our fishermen, who generally reckon in this way, call every *double pair* of herrings, for instance, a *throw* or *cast*; and the term *warp*, which, from its German origin, has exactly the same import, is employed to denote *four*, in various articles of trade.

Those simple arrangements would, at their first application, carry the reckoning but a very little way. To express larger numbers, it was necessary to repeat the process of classification. The ordinary steps, by which language ascends from particular to general objects, might point out the right path. A collection of *individuals* forms a *species*; a cluster of *species* makes a *genus*; a bundle of *genera* composes an *order*; and a group of *orders* perhaps constitutes a *class*. Such is the method indispensably required in framing the successive arrangement of the almost unbounded subjects of Natural History. A similar mode is pursued in the subdivision and distribution of the members of a vast army.

In following out the classification of numbers, it seemed easy and natural, after the first step had been made, to repeat the same procedure. If a heap of pebbles were disposed in certain rows, it would evidently facilitate their enumeration, to break each of those rows into similar parcels, and thus carry forward the successive subdivision till it stopped. The heap, so analysed by a series of partition, might then be expressed with a very few low numbers easily formed, and capable of being distinctly retained. The particular system adopted, would soon become clothed with terms borrowed from the vernacular idiom.

Let us endeavour to trace the steps by which a child or a savage, prompted by native curiosity, would proceed in classing, for instance, *thirty-nine* similar objects. He might be conceived first to arrange them by successive *pairs*. Selecting *thirty-nine* of the smallest shells or grains he could find, he would dispose these in *two* rows,

each containing *nineteen* counters, with *one* over. Having thus reduced the number to *nineteen*, he might subdivide this again, by representing only one of the rows with shells twice as large as before.

He would consequently obtain two rows of *nine* each, with an excess of *one*. Instead of these shells, were he to employ shells of a double size, it would be sufficient to denote one of the rows, or to dispose it into *two* rows. These rows contain only *four* counters with *one* over.

Again, by adopting counters of a double size, the last row might be represented by one pair,

each containing only *two* marks exactly. These again could be denoted by a *single pair* of counters, having twice the former dimensions.

As a final analysis, *one* counter, of double dimensions, will express the last row.—Hence the number *thirty-nine*, decomposed by repeated *pairing*, would be denoted by *one* counter of the *sixth* order, *one* of the *third*, *one* of the *second*, and another of the *first*.

Suppose a person should attempt to represent the same number, by *triple* rows of shells or counters. He would first have *thirteen* of the smallest shells in each row, and no more.

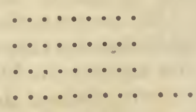
Then, expressing one of the rows by shells of *three* times the size or value, it would be again resolved into *three* rows, each containing *four* counters, with an excess of *one*.

Taking the *last* of these rows, therefore, and employing counters of triple size, it would be represented by *a column* of single counters, with *one* over.

Finally, this column would be marked by a single tripled counter.

—The number *thirty-nine* is thus expressed, on the system of *triplication*, by *a counter* of the fourth order, *one* of the third, and *another* of the second.

Lastly, conceive the number *thirty-nine* to be reckoned by *double pairs* or *quadruple* rows. Each row would then contain only *nine* counters, with an excess of *three*.



But a *single row* would express the same as all these *four*, if each counter in it were changed into another of quadruple size or value; and, consequently, this row might be again distributed into *four* ranks, each consisting of only *two* marks, with *one* left.

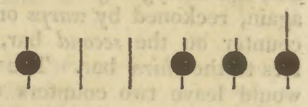
Retain one of these ranks, and substitute counters of *quadruple* effect, and *two* such will express the whole amount.

—Hence *thirty-nine*, analysed by the system of *double pairs* or *warps*, would be represented by two counters of the *third* order, one of the *second*, and three of the *first*.

In the ruder periods of society, a gradation of counters, accommodated to such a process of numerical analysis, was supplied by pebbles, grains, or shells of different sizes. This series, however, is very limited, and would soon confine the range of decomposition. To reach a greater extent, it was necessary to proceed by a swifter analysis; to distribute the counters, for instance, successively into ten or twenty rows, and to make pebbles, shells, or other marks, having their size only doubled perhaps or tripled, to represent values increased ten or twenty

fold. Beyond this stage in the progress of numeration, none of the various tribes dispersed over the vast American Continent seem ever to have passed. In the Old World, it is probable that a long pause of improvement had ensued among the nations which were advanced to the same point in the arts of life. But the necessity, in such arithmetical notation, of employing the natural objects to signify a great deal more than their relative size imports, would lead at last to a most important step in the ascent. Instead of distinguishing the different orders of counters by their *magnitude*, they might be made to derive an *artificial value* from their *rank* alone. It would be sufficient, for that purpose, to employ marks all of the same kind, but disposed on a graduating series of vertical bars or columns. The augmented value which these marks acquire in rising through the successive bars, would evidently be quite arbitrary, depending, in every case, on a key to be fixed by convention. This point in the chain of discovery was attained by the Greeks at a very early period, and communicated to the Romans, who continued, during their whole career of empire, to practise a sort of tangible arithmetic, which they transmitted to their successors in modern Europe. The Chinese also have, from the remotest antiquity, been accustomed to employ a similar mode of calculation, which they are said to manage with singular skill and address.

Resuming, therefore, the number *thirty-nine*; if it were distributed by successive *pairing*, it would be thus denoted on a series of six vertical bars.



The same number, decomposed by a repeated *trisection*, will assume a simpler appearance, being comprised in *four* bars.

But *thirty-nine*, when analysed by a succession of *double pairs*, would require for its expression six counters arranged on three bars.

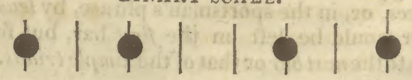
Suppose the objects to be reckoned were so numerous, that *one hundred and sixty-five* counters might be required to represent them. Placed in a single row, these counters would only give the very confused idea of multitude. But, if counted by *pairs*, or divided into two rows of *eighty-two* each, with an odd *one*, they would become a little more distinct. Were every counter now, in each row to denote a pair, a single row of them would have the power of both. Let this row be reckoned again by pairs, and it will change into two higher rows, each consisting of *forty-one* counters, without any excess. But one of these *third* rows would be sufficient alone, if each counter in it were esteemed equal to a *pair* in the *second* rows, or equal to a *duplicate pair*, or *four* in the *first* row. Again, tell one of the *third* rows over by pairs, and the *forty-one* counters will be converted into two *fourth* rows, containing *twenty* each, and *one* over. In like manner, each counter of a *fourth* row, being conceived equal to a pair in the *third* row, or a *triplicate pair*, that is, *eight* on the *first row*, a single row, including *twenty* of those higher counters, would have the same effect. Now, this *twenty* would be reduced to a pair of rows of *ten* counters each. Let each counter in the *fifth* row have the power of two in the *fourth* row, or of a *quadruplicate pair*, or *sixteen* in the *first row*; and *ten* such counters would be sufficient. But *ten* would give *five* pairs of *sixth* rows, one of which might denote the whole, if each counter in it were held equal to *two* in the preceding row, or to a *quintuplicate pair*, or *thirty-two* on the *first row*. Again, the last *five* counters would be divided into *two pairs* and *one* counter, and these two pairs into a *single pair* of a higher order.

This analysis appears tedious when so detailed, but it would proceed with great ease and rapidity in practice. The number *one hundred and sixty-five* would, therefore, on the system of successive *pairing*, be expressed by *one septuplicate pair*, *one quintuplicate pair*, *one duplicate pair*, and *one*. The language seems very uncouth, merely from its novelty and inaptness to our idiom; but its elements are extremely clear and simple. If a few cognate words had been devised to express the several combinations of pairs, or the ascending scale of the powers of two; it would have removed every objection.

Binary Scale.

This arrangement, whereby a number is analysed into certain elements by the operation of distributing it and its sections into successive *pairs* or *duads*, may be called the *Binary Scale*, of which *two* is the *root* or *index*. This scale, resting on so narrow a basis, expands slowly, and is therefore not very fit for expressing large numbers by words. But it is well adapted for the simplicity of emblematic exhibition. Suppose marks or counters were placed in perpendicular rows or parallel bars, proceeding from the right hand to the left, such that a counter on any bar should be equivalent to *two* laid on the bar immediately before it. Instead of putting the *hundred* and *sixty-five* counters on the *first* bar, it would be the same thing to leave *one* on that bar, and place *eighty-two* on the next. But instead of *eighty-two* counters on the *second bar*, the effect would be the same, to pass over it, and put *forty-one* on the *third bar*. Counting these *forty-one* also by pairs, we should leave *one* on the *third* bar, and carry *twenty* to the next. But twenty divided into successive pairs, would leave the *fourth* and *fifth* bars vacant, and throw *five* on the next. The *five* again would, after bisection, leave *one* on the *sixth* bar, and transfer *two* to the *seventh*; or, passing over this, they would carry *one* to the *eighth* bar. The decomposition thus effected would appear as below; where only *four* counters, and as many blanks, are sufficient to exhibit the number *one hundred* and *sixty-five*. By this elementary arrangement, a very distinct idea is conveyed: The eye can easily catch the picture, and the memory preserve it.

BINARY SCALE.



A similar effect would be produced, though much less clearly, by the combination of strokes, or of Runic sculpture, as thus represented.

Palpable Arithmetic.

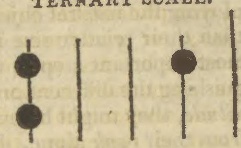
The advantages of the binary scale of notation were prodigiously extolled by the celebrated Leibnitz, who condescended even to write a discourse on its use and mode of adaptation. This very learned, original, and indefatigable philosopher, had the satisfaction to discover, from the researches of ingenious Missionaries, and particularly from the letters of Father Bouvet, some feeble traces of the *Binary Notation* in the early history of China. Fou-hi, the first Emperor and founder of that vast monarchy, is venerated in the East as a promoter of Geometry, and the inventor of a science, the knowledge of which has been since lost. The emblem of this occult science consists of eight separate clusters of three parallel lines or *trigrams*, drawn one above another, after the Chinese manner of writing, and represented either entire or broken in the middle. Those varied trigrams were called *Koua* or *suspended symbols*, from the circumstance of their being exposed in the public places. In the composition of such varied clusters, it was not difficult for the sagacity of Leibnitz to perceive the application of the *Binary Scale* carried only to three ranks, or as far as the number *eight*. The entire lines signify *one, two*, or *four*, according to their order, while the broken lines are void, and serve merely to indicate the rank of the others. Before this invention, the only mode of reckoning used in China was by knots tied on a single cord. In Plate XXVII. the Emperor is figured, pointing with a *stylus* at the two-fold progression; being copied exactly from the third volume of the *Mémoires sur les Chinois*, omitting only the grotesque portrait of the Sage. Those emblems were besides intended to convey a store of mystical or mythological knowledge. In the trigrams of Fou-hi, the pious and orthodox Missionaries could not fail to discover certain edifying traces of the mystery of the Trinity, at an epoch perhaps as remote as that of the Deluge.

The next Emperor, Chen-noung, devoted his attention chiefly to the improvement of agriculture. But he likewise extended the *Kona* or the dualic system of his predecessor, employing hexagrams instead of trigrams. These hexagrams were formed with six parallel lines, broken or entire, and placed one above the other. In short, they were the first six bars of the binary scale, of which the last term would represent thirty-two, and all the terms together would reach to *sixty-four*. *Chen-noung* contrived that the hexagrams should likewise exhibit sixty-four varieties of combination, by placing them in eight rays issuing from the same central space which was occupied by one of the eight trigrams. See *Mémoires sur les Chinois*, Tome II. p. 189, Planche viii.

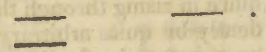
Ternary Scale.

The *Ternary Scale* of numeration, which reckons by successive *threes* or *triads*, advances with more speed. Thus, suppose, as before, that *one hundred and sixty-five* were to be exhibited on it. Counted by *threes*, or, in the sportsman's phrase, by *leashes*, no counter would be left on the *first* bar, but fifty-five thrown to the *next bar* or that of the *simple triads*. These fifty-five counters, being again told by threes, would leave one on the *second* bar, and carry eighteen to the *third* bar, or that of *duplicate triads*. This eighteen, counted twice in succession, would pass over the *fourth* and *fifth* bars, and throw *two* marks to *sixth bar*, or that of *quintuple triads*. The original number so decomposed, might therefore be denominated *two quintuple triads*, and *one single triad*. It is denoted by three counters, as in the form here annexed.

TERNARY SCALE.



The number might likewise be readily expressed, though less perfectly, by combined strokes or points.



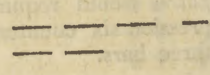
It is apparent that the *Ternary* Scale, though more powerful than the *Binary*, requires two sets of marks or counters. In the example now taken, each counter on the ascending bars represents *three, nine, twenty-seven*, or *eighty-one;* and the number itself is consequently split into two *eighty-ones* and *three*.

Quaternary Scale.

Let still the same number be arranged on the *Quaternary Scale* which proceeds by *Fours* or *Tetrads*. *One hundred and sixty-five*, told over by *double pairs* or *warps*, would leave *one* counter on the *first* bar, and carry *forty-one* to the next. This *forty-one* again, reckoned by *warps* or *throws*, would drop *one* counter on the *second* bar, and transfer *ten* counters to the *third* bar. The *ten* being now counted, would leave two counters on the *next* bar, and carry *two* to the *fourth* bar. The original number would therefore be described as containing *two triplicate tetrads, two duplicate tetrads, one tetrad and one;* and it would be designated in this manner:

QUATERNARY SCALE.

Or, if the less satisfactory mode of strokes were employed, *one hundred and sixty-five* would be thus exhibited.



This number is analysed into *twice sixty-four, twice sixteen, four*, and *one*. *Three* sets of counters would evidently be required to fit this scale for its application.

The *Quaternary Scale* may be considered as a reduplication of the *Binary*, each bar of the former comprizing two bars of the latter. This effect will appear more conspicuous by comparing the same number as it was exhibited on both scales. It is alleged that the Guaranis and Lulos, two of the very lowest races of savages which inhabit the boundless forests of South America, count only by fours; at least that they express five by four and one, six by four and two, and so forth. We may gather from Aristotle, that a certain tribe of Thracians were accustomed to use the quaternary scale of numeration; for he says that they proceeded no farther than *four*,*

* Μόνοι δὲ ἀριθμοῦσι τῶν Θρακῶν γένος τὶ ἐις ΤΕΤΤΑΡΑ. *Arist.* Problemat. xv. 3.

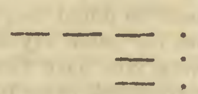
which they would doubtless continue to repeat. If such was the historical fact, those simple people must have never advanced beyond the early practice of reckoning successively by *casts* or *warps*. It seems probable that Pythagoras was acquainted with the quaternary system, which he brought from Egypt and India. Hence perhaps the mystical veneration which the followers of that philosopher professed to entertain for the *tetractys* or *quaternion*, the root of the scale, which contains besides, within itself, the number denoting the elementary musical proportions. Near the end of the seventeenth century, Weigelius seriously proposed, in Germany, the adoption of the *Tetractyc* or *Quaternary* numeration, which he explained, with copious detail, in a learned work entitled *Aretologistica.**

**Quinary Scale.**

To advance a step farther, let the same number be represented on the *Quinary Scale*, which reckons by the series of *fives* or *pentads*. Classed in this way, it would pass over the *first* bar, and throw *thirty-three* counters to the *second*. Told over again, it would leave *three* counters on the *second* bar, and carry *six* to the *third;* and the *six*, reckoned by *fives*, would drop *one* counter on the *third* bar, and advance one to the *next*. *One hundred and sixty-five* would therefore be denominated *one triplicate pentad, one duplicate pentad*, and *three single pentads;* and it would be thus denoted:

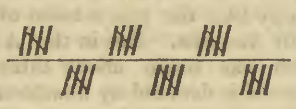
QUINARY SCALE.

This number might also be exhibited on the same scale by the combination of strokes with dots:



By this classification, the number *one hundred and sixty-five* is divided into *one hundred and twenty-five, twenty-five*, and *three fives*. The *root* or *index* of the scale being five, it would require *four* sets of counters to adapt it for practice.

The first bar of the *Quinary Scale* is actually used in this country among traders. In reckoning articles delivered, the person who takes charge of the *tale*, having traced a long horizontal line, continues to draw, alternately above and below it, a *warp* or four vertical strokes, each set of which he crosses by an oblique score, and generally, we believe, calls out *tally!* as often as the number *five* is completed.

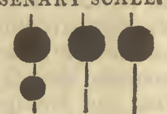

&c.

The *Quinary* system has its foundation in nature, being evidently derived from the practice of counting over the fingers of one hand. It appears accordingly, at a certain stage of society, to have been adopted among different nations. Thus, the Omaguas and the Zamucas of South America reckon generally by *fives*, which they call *hands*. The Toupinambos, a most ferocious and warlike race that inhabit the wilds of Brazil, would seem, according to the relation of Lery, to use the same kind of numeration. To denominate six, seven, and eight, those tribes only join to the word *hand*, the names for one, two, and three. The same mode, as we learn from Mungo Park, is practised by some African nations; particularly the Yolofs and Foulahs, who designate *ten* by *two hands, fifteen* by *three hands*, and so progressively. The *Quinary Numeration* seems likewise, at a former period, to have obtained in Persia, for the word *pentcha*, which denotes *five*, is obviously derived from the radical term *pendj*, signifying a *hand*.

**Senary Scale.**

When the index of the scale is larger, it often becomes inconvenient to place so many counters as are wanted on the same bar. But this notation may be abridged in the case where the index is even, by adopting a counter of greater dimensions, to signify the half of it. Suppose *one hundred* and *sixty-five* to be disposed in the *Senary Scale*, which proceeds by successive *sixes* or *hextads*. Parted into *six* rows, that number would leave *three* counters on the *first* bar, and cast *twenty-seven* to the next; this *twenty-seven*, being reckoned by sixes, would drop *three* counters on the *second* bar, and transfer *four* to the *third* bar. The original number would hence be described as *four duplicate hextads, three single hextads*, and *three*. But instead of placing *three* counters on the first and second bars, and *four* on the third bar, one large counter may supply the place of three; as in the form here annexed.

SENARY SCALE.



The *Senary* arrangement has few advantages to recommend it; yet it seems at one period to have been adopted in China, at the mandate of the Emperor CHE'-HOANG-TI. This capricious tyrant, who murdered the *literati* and burnt their books, having conceived an astrological fancy for the number *six*, commanded this to be used in all concerns of business or learning throughout his vast Empire. He directed a sort of arithmetic to be composed, with *six* for its basis; and he enjoined, that all weights and measures should be arranged on the same scale. He divided China into six times six, or thirty-six, provinces; and was so much enamoured of this favourite number, as to order his chariot to be just six feet long, and to be drawn by six horses, with only six attendants.

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* This writer even goes so far as to invent names for the several orders of his *Tetractyc System*. They will appear to have a sufficiently German air, though not harsher than the terms we now use.

| | | | | | |
|---|---|---|---|---|---|
| Second Order, or 4, | - | *Erff.* | Sixth Order, or 1024, | - | *Erff Schock.* |
| Third Order, or 16, | - | *Zwerff.* | Seventh Order, or 4096, | - | *Secht Schock.* |
| Fourth Order, or 64, | - | *Secht.* | Eighth Order, or 16384, | - | *Schock mahl schock.* |
| Fifth Order, or 256, | - | *Schock.* | | | |

Weigelii, *Aretologistica vel Logistica Virtutum Genetrix.* Norimbergæ, 1687.

Palpable Arithmetic.

Octary Scale.

Let the *Octary Scale*, which proceeds by successive *eights* or *octads*, be treated in a similar way. The original number, being reckoned by *eights*, would leave *five* counters on the *first* bar, and throw *twenty* to the next; and this *twenty* being told over again by *eights*, would leave *four* counters on the *second* bar, and carry *two* to the *third*. If, therefore, the large counter signify half the index, or four, *one hundred and sixty-five* will be thus denoted:

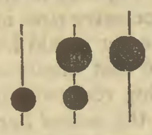
OCTARY SCALE.

The number is denominated *two duplicate octads*, *four single octads*, and *five*; and it has been decomposed into *two sixty-fours*, *four eights*, and *five*.

Denary Scale.

Suppose now that the *Denary Scale* of Notation were employed. The same number, reckoned by *tens* or *decads*, would leave *five* counters on the *first* bar, and cast *sixteen* to the *next* bar; which, being told again, would leave *six* counters on the *second* bar, and carry *one* to the *third*. This arrangement furnishes the denomination of *one duplicate decad*, *six single decads*, and *five*; which is simpler than any of the former appellations, and yet it sounds uncouth, owing merely to our want of familiarity with the terms. It would be marked in this way:

DENARY SCALE.



We are thus conducted by successive advances to that system of numeration which has prevailed among all civilized nations, and become incorporated with the very structure of language. This almost universal consent, clearly bespeaks the influence of some common principle. Nor is it difficult to perceive that the arrangement of numbers by tens would naturally flow from the practice so familiar in the earlier periods of society,—that of counting by the fingers on both hands. Aristotle in his Queries, points at this origin, but with a less decided tone than might have been expected from him.* The philosopher even hints at other concurring causes, some of which appear to be very fanciful. Such, for instance, is his conjecture, that the root of the denary scale might be derived from the summation of the numbers *one*, *two*, *three*, and *four*, included in the Pythagorean *tetractys*. If the original import and composition of the Greek terms, δεκα, ἑκατον, χιλια, and μυρια for ten, a *hundred*, a *thousand*, and *ten thousand*, could be safely traced, we might discern the influence of the denary system in the formation of those words. The Roman terms for numerals proceed not farther than *mille*, a *thousand*; but they are evidently of the same family, with some of the slighter modifications.

But the origin of the names imposed on the radical numbers, appears most conspicuously displayed in the nakedness of the savage dialects. The Muysca Indians, who formerly occupied the high plain of Bogota in the province of Grenada, were accustomed to reckon first as far as *ten*, which they called *quihicha* or a *foot*, meaning no doubt the number of toes on both feet, with which they commonly went bare and exposed; and, beyond this number, they used terms equivalent to *foot one*, *foot two*, &c. corresponding to *twelve*, *thirteen*, &c. Another tribe, who likewise inhabits South America, the Sabiconos, call *ten*, the root of the scale, *tunca*, and repeat only the same word, to signify an *hundred* and a *thousand*, the former being termed *tunca-tunca*, and the latter *tunca-tunca tunca*.

Etymology, guided by the spirit of philosophy, furnishes a sure instrument for disclosing the monuments of early conception, preserved though disguised, in the structure of language. Our own dialect as immediately derived from its Gothic stem, betrays a composition not less rude or expressive than the simple articulation of the Sabiconos. According to the authorities collected by a celebrated German philologist, the late very laborious and accurate Adelung, the word *eleven* was most anciently written *einlif* or *einlivin*, being compounded of *ein* or *one* and the verb *liban*, to *leave*, and therefore signified merely *one*, *leave*; that is, *retain one*, and *set aside* no doubt *ten*, the root of the scale. *Twelve* has the same etymon. The names *twenty*, *thirty*, *forty*, &c. have the terminating syllable *ty*, which corresponds to *zig* in German, and *zug* or *zuch* among the oldest writers of that parent tongue. This termination is derived from the verb *ziehen*, to *draw*, and hence *twenty* means simply *two drawings*, *thirty*, *three drawings*, &c. intimating evidently, that so many tens are separated from the heap. The term *hundred*, which also runs unvaried through all the filiations of the Gothic, is formed of *hund*, which anciently signified only *ten*, and *red* or *ret*, a participle from the verb *reitan* to *reckon* or *place in rows*: The compound would therefore intimate as much as *ten times told*, that is the reduplication of ten, or *ten added ten times*. In the Gothic Translation of the Gospels made by Ulphilas, in the fourth century, *one hundred* is expressed by *tachund tachund*, or the word for ten merely doubled; exactly like the *tunca tunca* of the Sabiconos of South America. But in the Anglo-Saxon version, which was made about three centuries later, *one hundred* is denoted by *hund teontig*, meaning *ten of ten drawings*. In the same curious monument of our early language, *hund seafontig*, or *ten of*

* "Διὰ τί πάντες ἄνθρωποι καὶ βάρβαροι καὶ ἕλληνες ἐς τὰ δέκα καταριθμοῦσι, καὶ οὐκ εἰς ἄλλον ἀριθμὸν, οἷον β. γ. δ. ε, (εἶτα πάλιν ἐπαναδιπλοῦσιν, ἓν πέντε, δύο πέντε,) ὥσπερ ἕνδεκα, δώδεκα οὐδ' αὖ ἐξωτέρω παυσάμενοι τῶν δέκα, εἶτα ἐκεῖθεν ἐπαναδιπλοῦσιν; ἔστι (μὲν) γὰρ ἕκαστος τῶν ἀριθμῶν, ὁ ἔμπροσθεν, καὶ ἓν ἢ δύο καὶ οὕτος ἄλλος τις. ἀριθμοῦσι δ' ὅμως ὁρίσαντες ἄχρι τῶν δέκα οὐ γὰρ δὴ ἀπὸ τύχης γε αὐτὸ ποιοῦντες φαίνονται, καὶ ἀεί. τὸ δὲ ἀεὶ καὶ ἐπὶ πάντων, οὐκ ἀπὸ τύχης, ἀλλὰ φυσικόν" And, after throwing out some loose conjectures, he subjoins: "ἢ ὅτι πάντες ὑπῆρξαν ἄνθρωποι, ΕΧΟΝΤΕΣ ΔΕΚΑ ΔΑΚΤΥΛΟΥΣ; οἷον οὖν ψήφους ἔχοντες τοῦ οἰκείου ἀριθμοῦ, τοῦτο τῷ πλήθει καὶ τἄλλα ἀριθμοῦσι." *Arist.* Problemat. xv. 3.

Palpable Arithmetic.

*seven drawings*, is employed to express *seventy*. It seems probable, that *hund* and *ten* or *teon* were only variations of the same word. The term a *thousand* is merely an abbreviation of *diuis-hund*, its earliest form. The prefix *diuis* is the same as the word *twice*, and *hund* was probably contracted for *one hundred:* The combined expression would, therefore, signify a *redoubled hundred*, or *one hundred repeated ten times*.

It is remarkable that the Peruvian language was actually richer in the names for numerals than the polished dialects of ancient Rome or Greece. The Romans, we have seen, went not farther than *mille*, a thousand; and the Greeks made no distinctive word beyond *μυρια*, or ten thousand. But, the inhabitants of Peru, under the Incas, following the *Denary System*, had the term *huc*, to denote *one; chunca, ten; pachac, one hundred; huaranca, a thousand;* and *hunu, a million*. These words are either original, or have been formed, like our numerical terms, by the abbreviation of certain compound expressions.

Philosophers, from Aristotle down to Locke, have too hastily given credit to the vague reports of travellers, concerning the very scanty knowledge which savages possess of the art of numeration. Even the cautious and discriminating historian Dr Robertson, thinks himself warranted to conclude, from authorities which he quotes, that certain tribes of native Americans could reckon no farther than ten, or perhaps twenty, while others advanced not beyond three. But, it is utterly repugnant to congruity, to suppose that any people should be found so destitute of mental faculties, as not to rise above those low numbers. It seems far more probable, that such numbers were merely the *roots* of the systems of classification adopted by the several tribes, and mistaken by unphilosophical travellers for the whole extent of their numeration. Every savage nation must surely be supposed capable of reckoning up the bands of warriors which they can bring into the field, amounting generally to hundreds, and often to thousands.

Roger Williams, one of the earliest settlers of New England, a man of sense and observation, though deeply tinctured with the enthusiasm of the age, published in 1643, a small Key to the language and manners of the Indian nations who then surrounded that infant colony, in which he gives an ample list of the numerals employed by the native tribes. It hence appears, that those people used the *Denary Scale* of arrangement, and had a set of distinct words to express the numbers as far as a *thousand*, and could even advance as high as *one hundred thousand*, by help of combined terms. Thus, *one* they named *nquit; ten, piùck; an hundred, pâwsuck;* and a *thousand, mittânug*. But these words are apparently compound, and would doubtless be found to throw much light on the subject of numeration, if we had any means of analysing them. The same author assures us, that the Indians, employing grains of corn for symbols, were very expert in their computations.

According to the testimony of Leems, a respectable Moravian missionary, the Laplanders, in their computations, join very significantly the cardinal to the ordinal numbers. Thus, to express *eleven* and *twelve*, they say *auft nubbe lokkai*, and *gouft nubbe lokkai;* that is, *one to the* SECOND *ten*, and *two to the* SECOND *ten*. In like manner, to signify *twenty-one* and *twenty-two*, those rude people use the expressions *auft gooalmad lokkai*, and *gouft gooalmad lokkai*, meaning *one added to the* THIRD *ten*, and *two added to the* THIRD *ten*. This procedure affords a curious and very happy illustration of the principle of numeral arrangement.

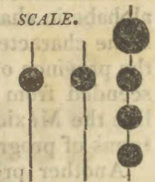
Duodenary Scale.

The *Duodenary System* of arrangement was introduced at a more advanced stage of society. It plainly drew its origin from the observation of the celestial phenomena, there being twelve months or lunations commonly reckoned in a solar year. The Romans adopted that index, to mark their subdivision of the unit of measure or of weight. They distinguished the *foot* into *three hand-breadths* or *palms*, and each *palm* into *four* lengths of the *thumb-joint* or *digit;* and, in like manner, they first bisected the pound, next bisected this again, and then divided the *quarter* into *three* final portions. The twelfth part of a foot and that of a pound were alike termed *uncia*, which has branched into the modern words *inch* and *ounce*, applied more discriminately with us to the subdivisions of *measure* and of *weight*.

The mode of reckoning by *twelves* or *dozens* has been very generally adopted in the wholesale trade. Nor is its application confined to the first term of the progression, but extends to the second or even the third. Twelve dozen, or *an hundred and forty-four*, makes the long or *great hundred* of the Northern Nations, or the *Gross* of traders. Twelve times this again, or *seventeen hundred and twenty-eight*, forms the *Double Gross*.

Let the same number, one hundred and sixty-five, as before, be reckoned on the *Duodenary Scale*. It contains *thirteen dozen* and *nine*, or *one gross one dozen and nine*, and consequently, will be represented as here annexed.

DUODENARY *SCALE.*



Next to the Denary Scale itself, the system of counting by progressive *scores* or *twenties*, derived from the same source, appears to have been the most prevalent. The savage who had reckoned the fingers on both hands, and then the toes on both feet, making *twenty* in all, might seem to have reached the utmost limit of natural calculation. The Guaranis, a very simple and inoffensive tribe, who live on the shores of the Marañon, are accordingly said to proceed no farther in their direct numeration. When these people want to signify *an hundred*, they only place in a row five heaps of maize, each composed of *twenty* grains. The Mexicans, however, being more advanced in society, were accustomed to employ the higher terms of the same progression, thus combining the *Denary* with the *Binary* scales. In the ancient hieroglyphic paintings of that unfortunate race, *units*, as far as a *score*, are exhibited by *small balls;* and *twenty* is denoted by a figure, which some authors, and particularly Clavigero, have mistaken for a *club*, but which was really a *small standard* or *flag*. In the same curious monuments, *twenty scores*, or *four hun-*

Palpable Arithmetic.

*dred*, is signified by *a spreading open feather;* probably, because the grains of gold, lodged in the hollow of a quill, represented, in some places, money or the medium of exchange. This symbol has, from the rudeness of the drawing, been taken at times for a pine-apple, an ear of maize, or even the head of a spear; but its application to intimate the *duplicate scores* is certain and invariable. A sack or bag, was also painted by those ingenious people, to represent *twenty times twenty scores*, or *eight thousand*. It was of the same form as a purse called *xiquipilli*, and supposed to hold *eight thousand* grains of cacao. To avoid the multiplication of the balls, and other symbols, the Mexicans sometimes divided the flag denoting a score by two cross lines, and coloured the one half of it to signify *ten*, or covered three quarters of it with colour to mark *fifteen*. This mode of abbreviating the signs was evidently capable of farther extension. Plate XXVII. exhibits the series of Mexican hieroglyphic numerals, copied from Humboldt's splendid work entitled *Vues des Cordilleres;* and to illustrate their application, we have represented the current *year* 1816, by help of them, having its circle prefixed as indicating a complete revolution of the four seasons.

Traces of numeration by *scores* or *twenties* still exist in the old continent. The expression *three score* and *ten*, in our own language, is more venerable than *seventy;* and the compound *quatre-vingts et dix*, is the ordinary mode in French for signifying *ninety*. The Arâbians, according to Sylvestre de Sacy, counted no farther than *four hundred* or *twenty scores*, before the sixth century of the Hejira, which corresponds to about the middle of the eleventh century of the Christian æra. To denote *nine hundred*, they had recourse to the clumsy expedient of redoubling the alphabetic character of *four hundred*, and joining to it the character of *one hundred*. The inhabitants of the province of Biscay, and of Armorica, people descended from the ancient Celts, are said to reckon like the Mexicans, by the powers of *twenty*, or the terms of progressive *scores*.

Another progression, still swifter in its operation than that by scores, and long familiar to Astronomers, was introduced into the Alexandrian school by the famous Ptolemy, who had the merit of digesting the results of celestial observations into a body of regular science. We allude to the *Sexagenary Scale*, which proceeds, as its name implies, by the successive powers of *Sixty*. This arrangement of numbers appears quite artificial, and was no doubt suggested by the division of the circle founded on astronomical phenomena. Since the year is composed of twelve months, containing each about thirty days, the round number, three hundred and sixty, was chosen as the most convenient for subdividing the ecliptic into degrees. But the radius of the circle, was naturally employed as a standard for the measuring of lines and arcs in general; and this being nearly the sixth part of the circumference, and comprising, therefore, about sixty degrees, the arcs themselves, or their multiples, when expressed by degrees, came to be reckoned by *Sixties*. The notation was effected by annexing a single dash for *Sixty*, two dashes for its duplicate, and three dashes for its triplicate.

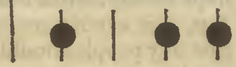
Palpable Arithmetic.

Since, in the notation by numeral scales, the import of a counter depends on the position of the bar on which it stands, any alteration of the place of units must produce a proportional change on the value of the whole amount of an expression. Thus, in the *binary* classification, the shifting of the bar of units one place lower, would, in effect, double all the preceding terms, and a second shift would double these again. In like manner, to carry the beginning of the scale a bar lower would, in the *denary* system, convert the units into tens, the tens into hundreds, and the hundreds into thousands; thus augmenting the whole tenfold. On the contrary, if the units were moved to a bar higher, the amount of any expression, would, in the *binary* scale, be reduced to one-half, and, in the *denary*, to the tenth part of its former value. Hence, to multiply or divide by the index of any scale or its powers, we have only to change the names of the bars, or to shift the place of the units.

Mode of representing Fractions.

The systems of progressive numeration are as well adapted to represent a descending as an ascending series; a property which greatly facilitates and simplifies the exhibition of fractions. Suppose, for example, it were sought to express *eleven-sixteenths* on the *Binary Scale*. Since a counter depressed by four bars will signify only the *sixteenth* of its original value, so *eleven*, reckoning upwards from the low bar, will express the value required.

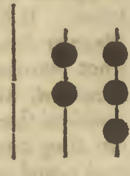
BINARY SCALE.



But the analysis of the fraction might be performed otherwise. It is evident, that *eleven-sixteenths* on the *first* bar, or the bar of units, are only equivalent to *twenty-two* such parts, that is, *one* counter and *six-sixteenths*, placed on the next descending bar. This excess again corresponds to *twelve* parts on the *second* bar, or *twenty-four* carried to the *third* bar, making *one* counter and *eight-sixteenths*. But these *eight-sixteenths* are equivalent to a whole counter on the *fourth* bar, where the exhibition stops. Hence the fraction proposed appears to consist of *one-half, one-eighth*, and *one-sixteenth*.

On the *Quaternary Scale*, this fraction would require only *two* bars, since *sixteen* is only the *second* power of the index *four*.

QUATERNARY SCALE.

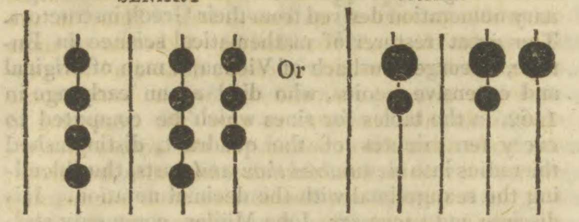


But the second mode of decomposition is, on the whole, simpler. The *eleven-sixteenths* of a counter on the bar of units, are equivalent to *forty-four*, or *two* counters, and *twelve* such parts on the next bar; and these *twelve-sixteenths* correspond to *forty-eight*, which compose *three* entire counters on the *third* bar. The original fraction is thus analysed into *two-fourths* and *three-sixteenths*.

To express the fraction on the *Senary Scale*, more bars are wanted. It is now equivalent, on the bar immediately after that of units, to *sixty-six-sixteenths*, or *four* counters and *two* parts. This small excess corresponds to *twelve* on the *third* bar, or *seventy-two* on the *fourth* bar, making *four* counters and *eight*

parts; which again correspond to *forty-eight*, or *three* entire counters on the fifth bar.

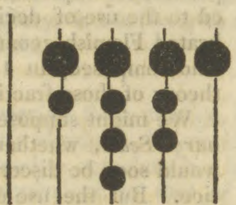
SENARY SCALE.




The fraction is thus resolved into *four-sixths*, *four-two-hundred and sixteenths*, and *three-twelve-hundred and ninety-sixths*.

Let the same fraction be represented on the *Denary Scale*. It might be found, that *sixteen*, multiplied by *six hundred and twenty-five*, produces *ten thousand*, or the *fourth* power of the index, ten. Wherefore *eleven* times *six hundred and twenty-five*, or *six thousand, eight hundred and seventy-five*, reckoned upwards from the fourth bar, below the rank of units, will denote the fraction proposed.

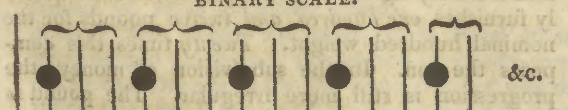
DENARY SCALE.



But the expression of this fraction on the descending scale is more easily and directly obtained, by the process of successive decomposition. *Ten* times *eleven sixteenths*, or *one hundred and ten* parts on the bar immediately below the units, make *six* counters and *fourteen* parts. These *fourteen* parts are equivalent to *one hundred and forty* parts, or *eight* counters and *twelve* parts on the *third* bar. This excess again gives *one hundred and twenty* parts, or *seven* counters and *eight* parts, for the *fourth* bar. And lastly, these remaining *eight* parts are represented by *five* counters placed on the *fifth* bar. The fraction *eleven sixteenths* is thus analysed into *sixteenths*, *eight-hundredths*, *seven-thousandths*, and *five-ten-thousandths*.

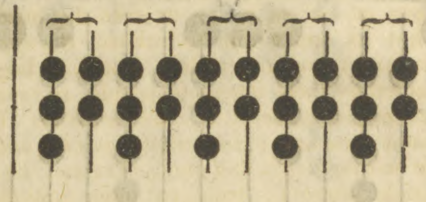
There is not the same facility, however, in decomposing all fractions, and reducing them to the terms of a descending scale. It often happens that the expressions for these will run through many bars, or even maintain a perpetual circulation, without ever drawing to a termination. Suppose, for example, that *four sevenths* were to be represented on the *Binary Scale:* It would correspond to *eight-sevenths*, or a counter and one part of the *second* bar; which excess would be equivalent to *two* parts on the *third* bar; *four* on the *fourth*, *eight*, or a *counter* and *one* part on the *fifth* bar. This bar would therefore leave out the same portion as the *second* bar; and consequently the notation would be continually repeated at the interval of three bars.

BINARY SCALE.




The same fraction would be thus expressed on the *Senary Scale*.

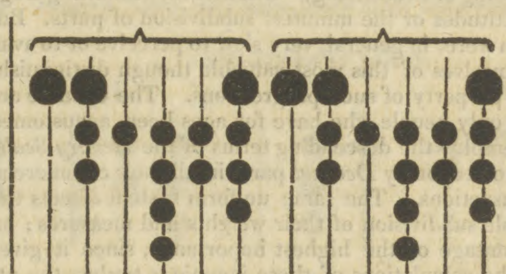
SENARY SCALE.



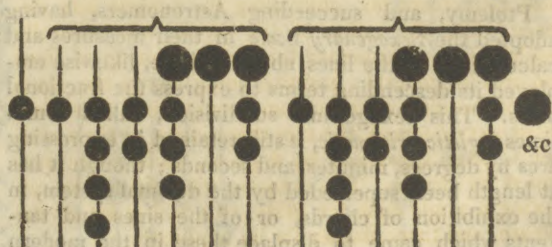

The *four sevenths* of a counter are here equivalent to *twenty-four* parts or *three* counters and *three* parts on the *second* bar: and these parts correspond to *eighteen* parts, or *two* counters and *four* parts on the *third* bar. The process of decomposition is hence incessantly renewed on the alternate bars.

If this fraction be reduced to the *Denary Scale*, the circulation will be still more complex. It will give for the *second* bar *forty* parts, or *five* counters and *five* parts; for the *third* bar, *fifty* counters, or *seven* counters and *one* part; for the *fourth* bar, *ten* parts, or *one* counter and *three* parts; for the *fifth* bar, *thirty* parts, or *four* counters and *two* parts; for the *sixth* bar, *twenty* parts or *two* counters, and *six;* and for the *seventh* bar *sixty* parts, or *eight* counters and *four* parts, which, being the same remainder as at first, will occasion the perpetual recurrence of the same series of counters.

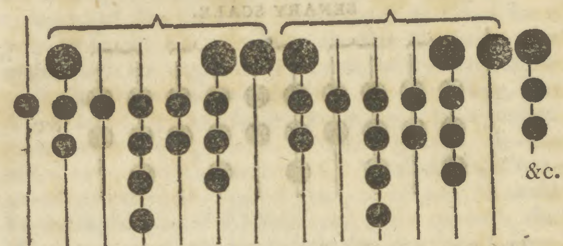
DENARY SCALE.




It is curious to remark with regard to the present example, that if the expression on the *Denary Scale* were multiplied by any number whatever, the same counters, and after the same order, would always appear to occupy the inferior bars: Thus, when doubled, it will assume this form, commencing like the *fourth* bar of the single expression.



If the expression for *four-sevenths* be *tripled*, it will show the same aspect, only beginning at the *third* bar:



&c.

A little reflection will discover the case to be an unexpected result. Since the perpetual succession of *six* bars, or only one less than the denominator, was necessary to represent the value of the given fraction; it follows, that every possible remainder arising from the repeated subdivision or decomposition by *seven*, must have some corresponding bar from which the same recurrence will take place. Thus, in the analysis of *four-sevenths*, the remainders on the successive bars were *five, one, three, two, four* and *six*; and consequently every fraction having *seven* for its denominator, would belong to one of these.

To reduce a fraction to any descending scale, may therefore prove a tedious, and often impossible task. But the converted expression approximates rapidly to its true value, and a very few terms will be sufficient for every practical use. The numerical scales are thus equally fitted by their constitution for ascending or descending,—whether for exhibiting huge multitudes or the minutest subdivision of parts. But men were, in general, very slow to perceive or to avail themselves of this most valuable though distinguishing property of such progressions. The Chinese are the only people who have for ages been accustomed to employ the descending terms of the *Denary Scale*, or to reckon by *Decimal* parts in all their commercial transactions. The same uniform system directs the whole subdivision of their weights and measures; an advantage of the highest importance, since it gives to the calculations of those ingenious traders the utmost degree of simplicity and readiness. The natives of India, who have so long been acquainted with the use of the *Denary Scale* of numeration, are yet ignorant of its application to denote fractions. Below the place of unity they change the rate of progression, and descend merely by a continued bisection, adopting successively the *half*, the *fourth*, the *eighth*, and the *sixteenth*; beyond which partition they seldom advance.

Ptolemy, and succeeding Astronomers, having adopted the *Sexagenary Scale* in their measures and calculations of the lines about a circle, likewise employed its descending terms to express the fractional parts. This sexagesimal subdivision, called sometimes *logistic arithmetic*, is still retained in expressing arcs by degrees, minutes, and seconds; though it has at length been superseded by the decimal system, in the exhibition of chords, or of the sines and tangents which came to displace these in the modern Trigonometry. Nor was the latter improvement embraced, or even contemplated at once. The Arabians, though well acquainted with the advantages of the *Denary Scale*, appeared satisfied with the sexagenary numeration derived from their Greek instructors. The great restorer of mathematical science in Europe, George Purbach of Vienna, a man of original and extensive genius, who died at an early age in 1462, in the tables for sines which he computed to every ten minutes of the quadrant, distinguished the radius into *six hundred thousand* parts, thus blending the sexagesimal with the decimal notation. His disciple and successor, John Müller, commonly styled Regiomontanus from Köningsberg, the name of his place of birth, after some hesitation laid aside this subdivision of the radius in 1464, and enlarged it to a *million* of parts, having recalculated the sines, and likewise joined to them tables of tangents. But his work lay many years after his decease in manuscript, and was not printed until 1533. A very long period still elapsed before mathematicians were trained to the use of decimals. Simon Stevinus, a celebrated Flemish geometer and engineer, was the first who composed, in 1582, a distinct treatise on the theory of those fractions.

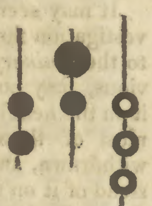
We might suppose that the properties of the *Denary Scale*, whether in ascending or descending, would soon be discerned and reduced to actual practice. But the use of fractions is associated with a more advanced state of society. Men very seldom take large and connected views of things; they generally grope their way step by step, as actual wants and circumstances chance to direct them. In the subdivision of the unit, they have often proceeded by *bisection*, sometimes by *trisection*, and frequently by joining together these modes, or combining them with *decimation*. This irregular and unsteady procedure is apparent in our own dissection of weights and measures. The simplest division is that of *halving*, which seems very naturally to spring from the competition between seller and buyer.—Our dry measure is, accordingly, broken down by a series of *bisections*. Thus, the chaldron is divided by a redoubled bisection into *four* quarters, each of these by a triple bisection into *eight* bushels, each of these again by a redoubled bisection into *four* pecks, each peck bisected into *two* gallons, each gallon by a redoubled bisection divided into *four* quarts, and each of these bisected into *two* pints. The avoirdupois weight, which is the sort generally used in business, appears both to ascend and descend, from a common point. The pound is divided by a quadruple bisection into *sixteen* ounces, and each of these again into *sixteen* drams. But were it desired that a hundred pounds should constitute the quintal, this would be reduced, by a successive quartering, to *six and a fraction*. Wherefore the nearest round number, *seven*, was taken, which being doubled gives *fourteen* pounds for a stone of horseman's weight, and this doubled again makes *twenty-eight* for the quarter, which consequently furnishes *one hundred and twelve* pounds for the nominal hundred weight. *Twenty* times this composes the ton. In the subdivision of money, the progression is still more irregular. The pound is

first divided into *twenty* shillings, next each of these into *twelve* pence, and then each *penny* into *four* farthings.

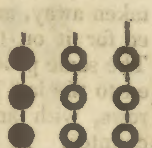
All the calculations in theoretical mathematics are now conducted invariably on the decimal scale. The same kind of subdivision has, to a certain extent, been introduced, for the sake of its great convenience, into the practice of gauging and land-surveying. But we may despair of ever seeing the decimal progression adopted in the general intercourse of society. The French have, indeed, set an example to the rest of Europe, in this case, at least, perfectly harmless, and highly worthy of imitation,—by framing a consistent and universal system of measures, weights, and coins, drawn from nature itself, and disposed with admirable simplicity and elegance. Yet, even in France, that seductive plan has, amidst the collision of opposite views and interests, experienced only a partial success. National prejudice, inflamed by ignorance, is too often opposed to every species of improvement; and the influence of a country, now shorn of her glory, is not likely to extend beyond her own frontiers.

When the index of a *Numerical Scale* is large, the notation may be conveniently abridged, by marking only what counters are wanted to complete any bar, or render its expression equivalent to that of an additional counter placed on the bar immediately before it. Thus, instead of *eight* counters on a particular bar, it would be sufficient to join *one* to the preceding bar, and put *two* defective or open counters in the *Denary Scale*, or *four* such counters on the *Duodenary Scale*. The same mode of contraction is alike applicable to the expression of integers, or of fractions. For the sake of illustration, let some of the former examples be resumed. The number *one hundred* and *sixty-five* was thus represented on the *Octary Scale*; there being *one* counter, and the substitute for *four* on the first bar, the same substitute on the second bar, and two counters on the first bar. Now add a counter to the second bar, and lay *three* open counters on the third bar, and this will be changed into the form annexed.

OCTARY *SCALE.*



This expression again is, by a similar process, converted into another, consisting of *three* open counters on the first and on the second bar, with *three* full counters on the third bar. Hence the number proposed, must consist of *three* duplicate octads, abating *three* octads and *three*, or is equal to *one hundred* and *ninety-two*, diminished by *twenty-seven*.



On the *Denary Scale*, the same number was denoted as under I. and will be successively changed into two other forms.

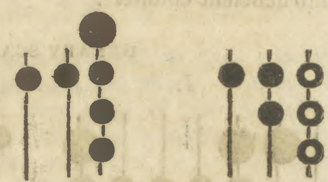
I. II. III.

The last expression, therefore, signifies *two hundred*, abating *thirty-five*.

Again, the number *one hundred* and *sixty-five*, which, on the *Duodenary Scale*, stood as annexed, will be reduced to the simpler expression; by changing the *three* counters, and *six* on the *first* bar for *three* open counters, and an additional counter on the second bar, intimating *one* gross and *two* dozens, abating *three*.

DUODENARY SCALE.

I. II.



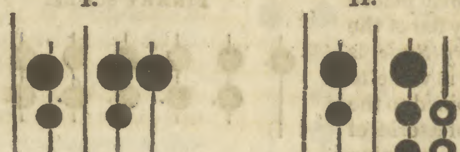
This method of employing open or deficient counters is applicable likewise to the notation of fractions. Thus, *eleven-sixteenths* expressed on the *Quaternary Scale*, may have these *three* different forms:

QUATERNARY SCALE.

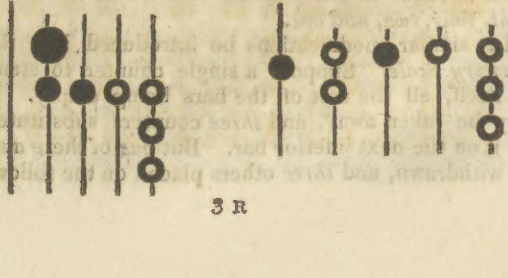
I. II. III.

On the *Senary Scale* this fraction will admit of more varieties:

I. II.



III. IV.

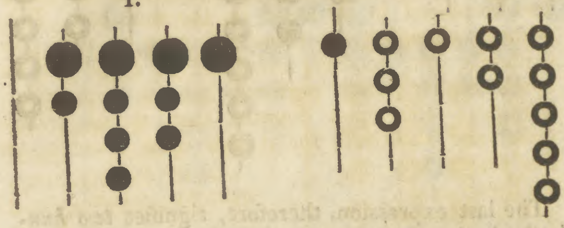


Palpable Arithmetic.

On the *Denary Scale*, this fraction may have its first expression changed, by successive modifications, into a simpler form.

DENARY SCALE.

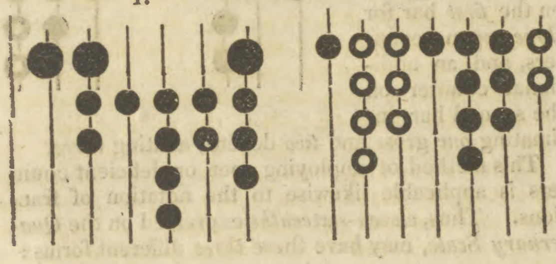
I. II.



The fraction *four-sevenths*, which, on the *Denary Scale*, formed a perpetual recurrence, may be abbreviated in the same way. The first expression is converted into another more commodious one, by changing the counters that exceed *five* on any bar into deficient counters.

DENARY SCALE.

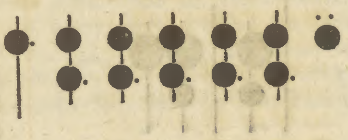
I. II.



General properties of these Scales.

We shall now investigate some general properties of those *Numerical Scales*. Suppose, in the *Binary Progression*, there was standing but a single counter on a high bar. It is obvious, that this might be removed, and *two* placed on the inferior bar. But *one* of these might likewise be removed, and *two* counters substituted for it on the next bar lower. The same process could be pursued through any number of bars, the removed counters being always marked by a dot, and the one which is finally rejected placed on the outside of the last bar with two dots over it. It hence appears, that *one* placed on any bar of the *Binary Scale*, is equal in value to *one* joined to the sum of a series of units running through all the inferior bars. Thus, in the example now produced, *one* counter occupying the *sixth* bar, and therefore indicating the number *thirty-two*, is equal in effect to *one* annexed to the sum of *sixteen*, *eight*, *four*, *two*, and *one*.

BINARY SCALE.

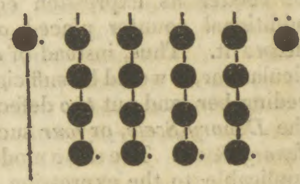


Let similar modifications be introduced into the *Ternary Scale*. Suppose a single counter to stand by itself, all the rest of the bars being empty. It may be taken away, and *three* counters substituted for it on the next inferior bar. But *one* of these may be withdrawn, and *three* others placed on the following bar: Of this triplet, the undermost might again be removed, and *three* substituted for it on the next bar. The same process, it is evident, could be repeated, till the change reached the lowest bar, leaving out an excess of *one*, marked by two dots to signify its being transferred. Hence the single counter on the *Ternary Scale* is, by successive mutations, converted into *two* rows of counters extending through all the inferior counters, and leaving an excess of *one*. Thus the number *two hundred* and *forty-three*, the value of a counter placed on the *fifth* bar of the *Ternary Scale*, is equal to *one* added to double the sum of *eighty-one*, *twenty-seven*, *nine*, *three*, and *one*, the values of counters occupying all the inferior bars.

TERNARY SCALE.

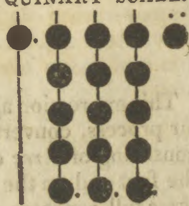
In like manner, if a solitary counter in the *Quaternary Scale* be withdrawn, *four* counters may be substituted on the next bar. Remove the undermost of these, and set *four* more on the succeeding bar. Take away *one* of these again, and put other *four* counters on the adjacent bar. Proceed in the same way, till the quaternion reaches the last bar, and is reduced to a triplet, by the exclusion of *one* counter. By this analysis, therefore, the simple counter is resolved with an excess of *one*, into *three* rows of counters which run through the whole of the lower bars. In the present instance, the number *two hundred and fifty-six*, the import of a counter on the *fifth* bar of the *Quaternary Scale*, is equivalent to *one* joined to *triple* the sum of *sixty-four*, *sixteen*, *four*, and *one*, the values of all the succeeding bars.

QUATERNARY SCALE.



It may seem scarcely necessary to pursue this investigation farther; but we shall extend it likewise to the *Quinary Scale*. A single counter, it is obvious, may now be removed, and *five* substituted for it on the next bar. The undermost of these again may be withdrawn, and *five* placed instead of it on the following bar. One of these may then be taken away, and *five* substituted for it on the adjacent bar. The same procedure is repeated to the last bar, leaving *four* rows, with an excess of *one* counter. In the present instance, a single counter on the *fourth* bar, and corresponding, therefore, on this scale the number to *six hundred and twenty-five*, is equivalent to *one* added to *four* times the sum of *one hundred and twenty-five*, *twenty-five*, *five*, and *one*, the values of all the inferior bars.

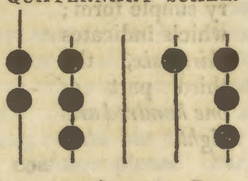
QUINARY SCALE.



Palpable Arithmetic.

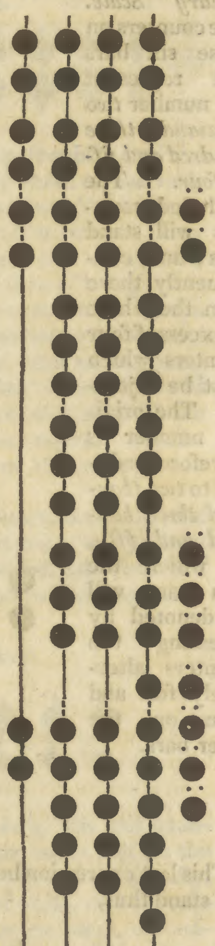
We may hence conclude in general, *that if one be taken from any power of the index of any numerical scale, the remainder will be equal to all the inferior powers repeated as often as the index, when diminished by one, contains unit.* Wherefore if the counters, reckoned as mere units, be separated from any compound expression, the whole will be converted into as many trains of counters, occupying all the inferior bars as correspond to the index of the scale diminished by one. Suppose, for example, the expression here noted, which is disposed on *five* bars, of the *Quaternary Scale*, and is equivalent to *seven hundred and eleven.*

QUATERNARY SCALE.



By decomposing separately each successive bar, and placing the excluded counters close beside the place of units, it will be changed into this regular but complex form, which consists of three rows of double counters, leaving out two; three rows of triple counters, leaving out three; a single counter, leaving out one; and three counters on the last bar left out. If we omit the *nine* excluded counters, and take only each single row of the rest, the result will be greatly simplified. This reduced expression corresponds to *two hundred and thirty-four.* But *seven hundred and eleven,* diminished by nine, the number of counters at first employed, leaves *seven hundred and two;* and this again, being divided by three, gives *two hundred and thirty-four.*

QUATERNARY SCALE.

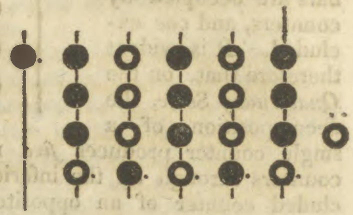


Applying this principle to the *Denary Scale*, it must follow, *that if the sum of the integers be subtracted from any number, the remainder will be divisible by nine, and the quotient will be equal to the sum of the separate numbers denoted by each of those integers repeated through all the inferior places.*

Palpable Arithmetic.

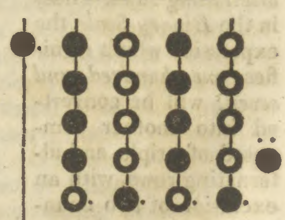
Another similar property, belonging to numerical scales, may be deduced from the combination of the deficient or open counters. Let us begin with the *Binary System.* Suppose a solitary counter to occupy the *sixth* bar. It may be removed, if *two* counters be placed in its stead on the next bar. But, without changing its value, we may to this pair evidently join another, composed of a full and an open counter, which perfectly balance each other. Withdraw the open counter that stands undermost, and substitute for it two open counters on the fourth bar. To these again, add a balanced pair, consisting of an open and a full counter. Take away the undermost counter, set two similar counters on the third bar, and to this pair annex a full and an open counter. By continuing this process, the single counter will be decomposed into *three* rows of counters, alternately full and open; with an excluded counter, which is open when the number of the bars, as in the present case, is even, but a full counter if that number be odd. Thus *thirty-two,* the value of the counter on the sixth bar, is equal to *three* times all the inferior alternating bars, or the excess of *sixteen* above *eight*, joined to the excess of *four* above *two*, and together with *one*, that is, *eleven;* abating, however, the excluded counter which is here open; but thrice *eleven*, omitting *one*, is *thirty-two.*

BINARY SCALE.



Let a similar analysis be applied to the *Ternary Scale.* Change the solitary counter for *three* counters laid on the next bar, and to these join a balanced pair consisting of a full and an open counter. Remove this open counter, and substitute three open counters for it on the succeeding bar, and to the triplet annex an open and a full counter. Take away the full counter, and place three such counters on the following bar. Repeat the procedure, till the *first* bar comes to be occupied; and there will evidently emerge *four* rows of counters extending through all the inferior bars, and alternately full and open, with an excluded counter of an opposite character to those which terminate the decomposition. In the present instance, where the single counter stood on the *fifth* bar, a counter of the ordinary kind is left out. Wherefore the number *eighty-one* is equal to four times the amount of the excess of *twenty-seven* above *nine*, and of that of *three* above *one*, or *twenty*, together with the *unit* excluded.

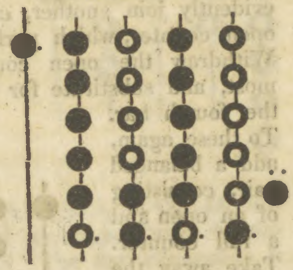
TERNARY SCALE.



It may be deemed sufficient for grounding a general conclusion, to repeat the same process on the

*Quaternary Scale.* Instead of the solitary counter, place *four* counters on the next bar, and conjoin with these a balanced pair of counters, composed of a full and an open one. Remove the undermost of these, and substitute four open counters on the following bar. To these again, add an open and a full counter, which will not affect the value of the column. Pursue the operation till all the bars are occupied by counters, and *one* excluded. It is evident therefore that, on the *Quaternary Scale*, the decomposition of a single counter produces *five* rows of alternating counters through all the inferior bars, with an excluded counter of an opposite nature to that of the row which completes the analysis. In the example now given, the number *two hundred and fifty-six*, the value of the counter on the *fifth* bar, is equal to five times the amount of the excess of *sixty-four* above *sixteen*, and of *four* above *one*, or *fifty-one*, together with the *unit* left out.

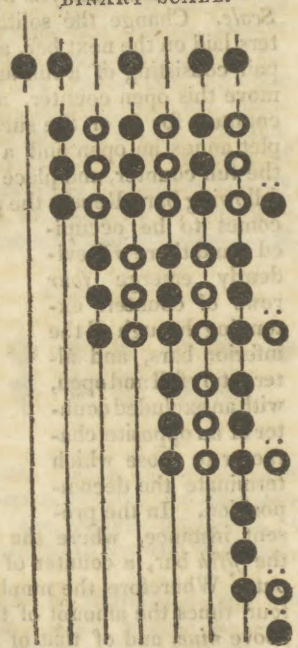
QUATERNARY SCALE.



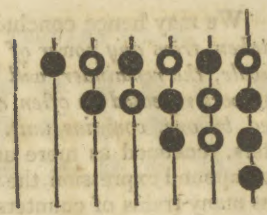
The conclusion may, therefore, be extended to any progressive scale: If the value of unit on a separate bar be increased or diminished by one, according as the rank is even or odd, the remainder will be divisible by one greater than the index of the scale, and the quotient will be equal to the amount of the values of unit as alternating in excess and defect through all the inferior bars.

The same property, it is evident, could be transferred to any compound expression: Nothing is wanted but to change the counters on each successive bar into alternating rows. Thus, in the *Binary Scale*, the expression which signifies *one hundred and seven*, will be converted into another composed of triple and alternating rows, with an exclusion of two counters in excess, and three in defect, or the balance of an open counter.

BINARY SCALE.

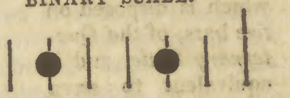


If this arrangement be now divided by three, the result, after restoring the deficient unit, will be



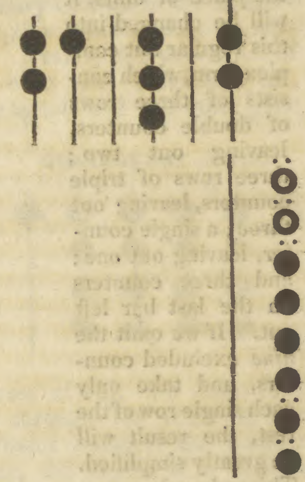
By collecting and condensing the counters on each bar, the whole will be reduced to another very simple form; which indicates *thirty-six*, the third part of *one hundred and eight*.

BINARY SCALE.

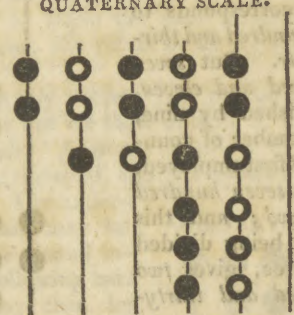


Let another example be selected from the notation of the *Quaternary Scale*. The counters on these six bars will represent the number *two thousand three hundred and fifty-four*. The excluded counters will stand thus; and, consequently, there is on the whole an excess of four counters which must be rejected. The original number is therefore reduced to *two thousand three hundred and fifty*, of which the fifth part will be denoted by repeating the counters alternately full and open on the lower bars.

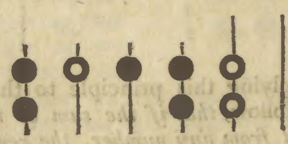
QUATERNARY SCALE.



QUATERNARY SCALE.

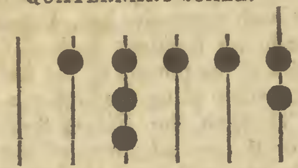


This last expression being condensed and abridged will stand thus,



or with full counters only,

QUATERNARY SCALE.



denoting *four hundred and seventy.*

In all these decompositions, we have stopped at the bar of units; but if we pursue the analysis through the descending bars, we shall discover trains of equivalent fractions which never terminate. Thus, to begin with the *Binary Scale:* A counter on the bar of units may be taken away, and two counters placed instead of it on the following bar. Of this pair again,

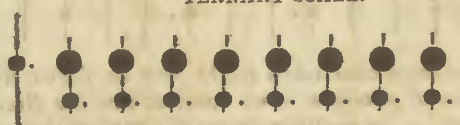
BINARY SCALE.

&c.

one may be removed, and another pair substituted for it on the next lower bar. One of these again may be withdrawn, and two placed on the following bar. The same operation of exchange, it is obvious, may be repeated for ever. Wherefore, the value of a single counter is here the same as that of a single row of counters, extending indefinitely over the lower bars. But the counter on the bar immediately below the place of units, indicates *one-half,* that on the next *one-fourth,* that on the following bar *one-eighth,* and so forth continually. Wherefore the sum of the fractions *one-half, one-fourth, one-eighth, one-sixteenth,* extended without limit, must always approach to *one.*

Let a similar transformation be carried through the *Ternary Scale.* Suppose a half counter to stand on the bar of units: It may be removed, and *three* half counters, or a whole counter and half of one sub-

TERNARY SCALE.

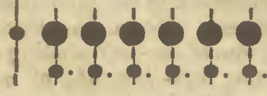


&c.

stituted on the next bar. Take away this half counter, and set *three* such, or a counter and a half on the succeeding bar. Repeat the same process continually, and the half counter on the bar of units, will be converted into a single row of entire counters, extending without limitation through all the inferior bars. But these successive counters signify *one-third, one-ninth, one-twenty-seventh,* &c. Whence the fraction *one-half* is equal to the sum of *one-third, one-ninth, one-twenty-seventh,* &c. continued *ad infinitum.*

In the *Quaternary Scale,* let the *third* of a counter occupy alone the bar of units. It may be withdrawn, and *four* such parts, or a whole counter, and the *third* of one placed in its stead on the next bar.

QUATERNARY SCALE.

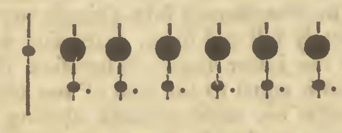


&c.

This *third* again may be removed, and a counter, with another *third,* substituted for it on the following bar. The same procedure being repeated, the *third* part of a counter in the place of units will be changed into a row of entire counters running through all the inferior bars. It therefore follows, that the fraction *one-third,* is equal to the sum of the infinite series *one-fourth, one-sixteenth, one-sixty-fourth,* &c.

Again, let similar modifications be carried through the *Quinary Scale.* The fourth of a counter on the bar of units may be exchanged for *five* such parts, or one counter and a quarter on the following bar; and this quarter may now be removed, and *five quarters,* or *one* counter and a *quarter* set on the next bar. The process of decomposition may thus be continued perpetually, leaving, instead of the *fourth* of a counter, an unlimited range of counters stretching over the inferior bars.

QUINARY SCALE.



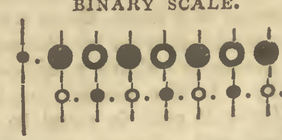
&c.

Consequently the fraction *one-fourth* is equal to the aggregate terms of the progressive *one-fifth, one twenty-fifth, one hundred* and *twenty-fifth, one six hundred* and *twenty-fifth,* continued without termination.

From these very simple analyses, we may therefore conclude in general, that the fraction of unit, which has for its denominator one less than the index of any numerical scale, is equal to the sum of all the descending powers, or the value of a single row of counters, extending indefinitely through the inferior bars. Thus *one-ninth* is equal to a *tenth,* a *hundredth,* a *thousandth,* &c. or *one-eleventh* is equal to a *twelfth* part, a *hundred* and *forty-fourth,* a *thousand seven hundred and twenty-eighth,* &c.

But the summation of a descending series, whose terms alternate, may with equal facility be discovered, by introducing the admixture of deficient counters. Thus, in the *Binary Scale,* if the *third* part of a counter stood on the bar of units, it could be removed, and *two-thirds* of a counter, that is, a whole counter *abating the third part,* substituted for it on the next bar. But this open part of a counter might be taken away, and a *whole* open counter diminished by the *third* part of a full counter placed on the following bar. This *third* again could be withdrawn, and a *full* counter with a deficient *third* part of one set on the next bar.

BINARY SCALE.



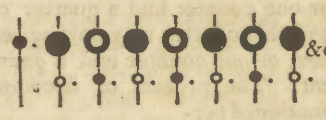
&c.

This alternate exchange might easily be repeated over the suc-

cessive bars. The *third* part of a counter is thus converted into an unlimited row of full and open counters. Hence the fraction *one-third* is equal to the sum of *one-half* abating *one-fourth*, of *one-eighth* abating *one-sixteenth*, of *one-thirty-second* abating *one sixty-fourth*, or equal to the excess of the continued series *one-half, one eighth, one thirty-second*, &c. above the corresponding series *one-fourth, one-sixteenth, one sixty-fourth*, &c.

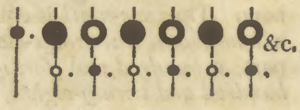
The substitution may, in like manner, be performed on the *Ternary Scale*. Suppose the *fourth* part of a counter to occupy the bar of units. Remove this fragment and substitute *three-quarters*, or a whole counter abating *one-quarter*, on the next bar. Instead of this deficient quarter again, place three such, or one open counter, conjoined with the quarter of a full one, on the succeeding bar. Pursue the same procedure, and the quarter of a counter will be transformed into a single row of counters, alternately full and open, extending without limitation over the lower bars. Wherefore the fraction *one-fourth* is equal to the sum of *one-third* abating *one, ninth*, of *one twenty-seventh* abating *one eighty-first* of *one two hundred* and *forty-third*, abating *one seven-hundred* and *twenty-ninth*, &c.; or *one-fourth* is equal to the excess of the perpetual series *one-third, one twenty-seventh*, &c. above the similar series, *one-ninth, one eighty-first*, &c.

TERNARY SCALE.




Another instance will be sufficient to point out the general principle. Let *one-fifth* part of a counter stand on the bar of units in the *Quaternary Scale*. It may be removed, if *four-fifths*, or one counter wanting a *fifth*, were placed on the next bar. Instead of this open *fifth*, let *four* open *fifths*, or *one* open counter, joined to a *fifth* of excess, be put on the following bar. Change this *fifth* again for a full counter, with a deficient *fifth* on the following bar. A series of alternating counters is thus successively formed. Whence the fraction of *one-fifth* is equal to the continued series *one-fourth*, abating *one-sixteenth, one sixty-fourth*, abating *one two hundred fifty-sixth*, &c.

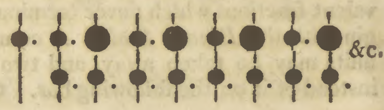
QUATERNARY SCALE.




We may hence infer generally, *that the fraction of unit, divided by one greater than the index of a numerical scale, is equal to the amount of all the descending powers taken alternatively as additive and subtractive.* Thus, *one-eleventh* part is equal to the excess of a *tenth* above a *one-hundredth*, that of a *thousandth* above a *ten-thousandth*, that of a *hundred thousandth* above a *millionth*, and so forth continually. In like manner, on the *Duodenary Scale*, the *thirteenth* part is equal to a *twelfth*, abating the *hundred* and *forty-fourth*, the *seventeen-hundred* and *twenty-eighth*, abating the *twenty thousand seven hundred* and *thirty-sixth*, &c.

In all these transformations of fractions, arising from the index of the numerical scale, increased or diminished by *one*, the operation is repeated or alternated at each successive bar. But similar changes may be made on fractions derived from the same modifications of the powers of the index, which will regularly circulate along the bars at a corresponding interval. Thus, on the *Binary Scale*, the fraction *one-third*, or the second power of the index two diminished by one, will form by decomposition an intermitting row, or a perpetual circulation, passing over the successive alternate bars. For *one-third* of a counter on the bar of units is equivalent to *two-thirds* on the following bar, which again are equal to *four-thirds*, or an entire counter and a *third*, on the next bar. Pursuing the same analysis, a row of counters emerges on the alternate bars. In reality, if the intermediate bars, which here serve only for the transit of the pair of *thirds*, were left out altogether, the notation would pass into that of the *Quaternary Scale*, and obey the general rule.

BINARY SCALE.




Again, on the same *Binary Scale*, the fraction *one-seventh*, or the reciprocal of the third power of two, diminished by *one*, will be found to circulate at every *third* bar. Thus, *one-seventh* of a counter on the bar of units gives *two* such parts for the second bar, *four* for the *third* and *eighth*, or a whole counter and an excess of *one-seventh* for the *fourth* counter; and if this kind of decomposition be carried forward, another counter will appear on the *seventh* bar, a *third* on the *tenth* bar; and so forth in perpetual succession.

BINARY SCALE.


But the same conclusion might also be drawn from the general principle, if we consider that the *Binary Progression*, by omitting always two consecutive bars, is converted into the *Octary Scale*.

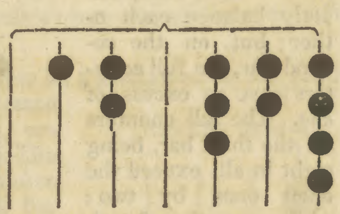
It is not difficult to perceive, that every fraction is capable of being either exactly represented on any given scale, or of being denoted by an expression which circulates after an interval of fewer bars than the denominator of the fraction contains units. In fact, the moment the same set of fractional counters comes to appear a second time, the whole expression must evidently recur in the same order. But all the possible variations or series of remainders must ever lie within the number itself, which constitutes the di-

Palpable Arithmetic.

visor. Thus, it was found that the expression for any fraction having the denominator *seven*, circulates on the *Binary Scale*, at the interval of *three* bars. The same fraction represented on the *Quaternary Scale* has a like recurrence; but, on the *Octary Scale*, the expression is renewed at every *two* bars, while it does not circulate till after passing over *six* bars, in the *Ternary*, *Quaternary*, *Quinary*, and *Denary Scales*. Employing a similar decomposition, it will appear that a fraction, with *eleven* for its denominator, will, in the *Quaternary* and *Quinary Scales*, circulate on *five* bars, but will embrace no fewer than *ten* bars, by its circulation in the *Ternary*, *Quaternary*, *Senary*, *Octary*, and *Denary Scales*.

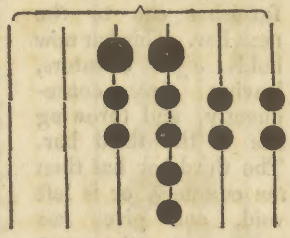
We may hence reverse the operation, and determine the absolute value of any circulating expression, or discover the fraction of which it is only the continued expansion. Suppose the group of counters here presented to circulate perpetually, at an interval of six bars on the *Quinary Scale*. If these counters were all transferred to the *seventh*, or last bar, they would signify *four thousand four hundred and sixty-four*. But another scale might be substituted, such that each single bar shall correspond in effect to this condensed *seventh* bar. Consequently the index of this new scale, or the *sixth* power of *five*, being diminished by *one*, will denote the denominator of the absolute fraction; which is therefore *four thousand four hundred and sixty-four* divided by *fifteen thousand six hundred and twenty-four*, or by reduction *two-sevenths*.

QUINARY SCALE.



In like manner, on the *Denary Scale*, let a set of counters always circulate, spreading over six successive bars. Conceive them transferred to the last bar, and they will express *seventy-six thousand nine hundred and twenty-three*. But if another scale were adopted, each bar of which had a power equal to six of these bars, its index would be *a million*. One less than this is consequently the denominator of the fraction, which is therefore equal to *one thirteenth*.

DENARY SCALE.



Theory, with Examples of Arithmetical Operations.

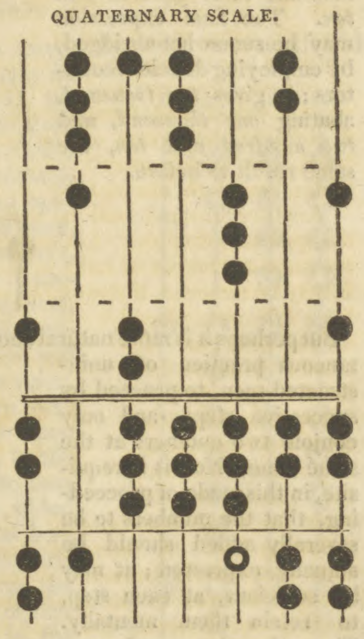
Having considered at some length the properties of numerical scales, and their various transformations, we have now to explain the ordinary operations performed on numbers themselves. These operations are all reducible to two very simple changes,—the *conjoining* and the *separating* of numbers. When two or more numerical expressions are *conjoined*, that is, condensed into a single expression, or collected into one *sum*, the process is called *Addition*. But when one numerical expression is *separated* or drawn out from another, leaving only a *difference* or *remainder*, the process is called *Subtraction*. If the *addition* should be employed merely in repeating the same number, it admits of abbreviation, and is then termed *Multiplication*. On the contrary, if the *subtraction* be limited to the continued withdrawing of the same number from another, the process becomes capable of abridgment, and is termed *Division*.

Palpable Arithmetic.

### Addition.

The whole operation consists in collecting and condensing the separate expressions. Beginning with the lowest bar, the counters are gathered together, and if they exceed the index of the scale, this excess only is retained, and *one* counter annexed or carried to the next bar. But if the counters on any bar should contain the index more than once, the number of repetitions is transferred a place higher, while the remainder of the reckoning is left as it stood. A very few examples will render the mode of proceeding quite clear. Let it be required to collect the expressions here disposed on the *Quaternary Scale*. On the bar of units, *two* counters occur, which are brought together at the bottom. *Two* counters are likewise found on the next bar, and each of the three following bars has each *three* counters. But *four* counters are found on the next bar, which are equal to *one* transferred to the highest bar, leaving a *blank* in their own place. In this case very little change in the notation is wanted; and except in a single transfer to a higher bar, the counters are merely brought closer together, and form the expression at the bottom. This again might be somewhat abridged by introducing open counters, as represented here, below the other. The sum of the three compound numbers thus represented on the *Quaternary Scale*, is therefore by reduction *nine thousand two hundred and ten*.

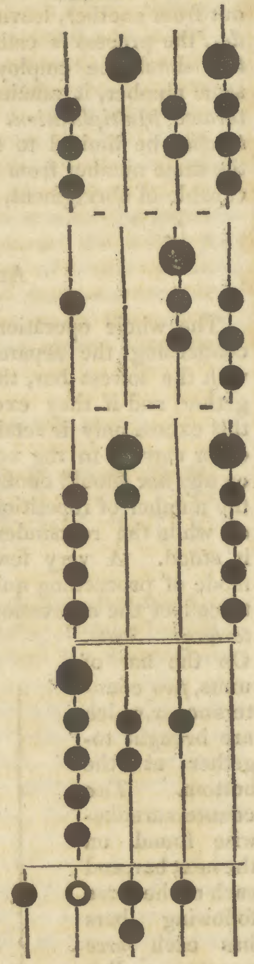
QUATERNARY SCALE.



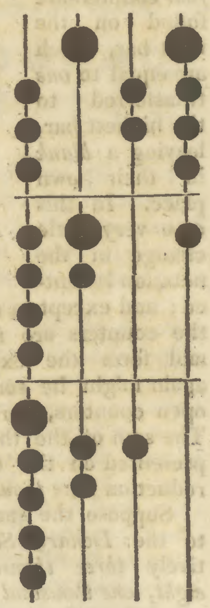
Suppose the same numbers were converted into the *Denary Scale*. They would be respectively *three thousand five hundred and twenty-eight*, *one thousand and seventy-three*, and *four thou-*

sand six hundred and *nine*; which are thus exhibited successively on four bars. Now, collecting all the single counters on the first bar to the right, they amount to ten, which joined to the two *fives* make *twenty*; they consequently, in their summation, leave that bar void, and throw *two* counters to the next. These *two* counters now joined to the *four* which occur on the second bar, make *six*, and again with the *five*, *eleven*, leaving *one* counter on the second bar, and furnishing *one* to the next. This counter, with another already on the third bar, leaves *two*; while the two *fives* on it deliver one on the fourth bar. The result, as before, is *nine thousand three hundred and ten*. The final expression may be somewhat abridged, by employing deficient counters; it gives *ten thousand*, abating *one thousand*, and *two hundred* and *ten*, the same result as before.

DENARY SCALE.

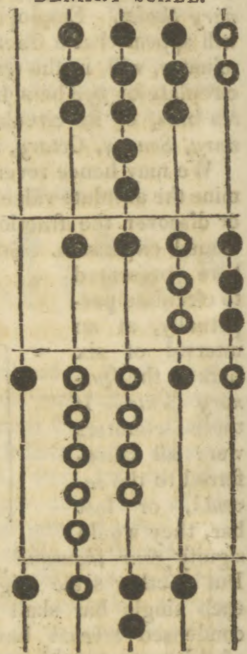


But perhaps it is more natural and more like the spontaneous practice of uninstructed men, to proceed by successive steps, and only conjoin two numbers at the same time. Nor is it requisite, in this mode of proceeding, that the numbers to be severally added should be actually expressed; it may be sufficient, at each step, to retain them mentally. Thus, when the second number is to be added to the first, the *three* counters which should occupy the first bar being joined, the *three* single ones already noted make *six*, or leave *one*, and change the other *five* into *ten*, which furnishes *one* counter to the second bar; and *one* counter on the fourth bar increases its stock to *four*. Again, when the third number is added, it would give *nine* counters to the first bar, and hence change it into *ten*, leaving the bar void, and throwing a counter to the next bar. But the *six* counters on the third bar, convert the *five* counters into *ten*, and thus furnish *one* to the next bar, while they leave *two* counters behind them.



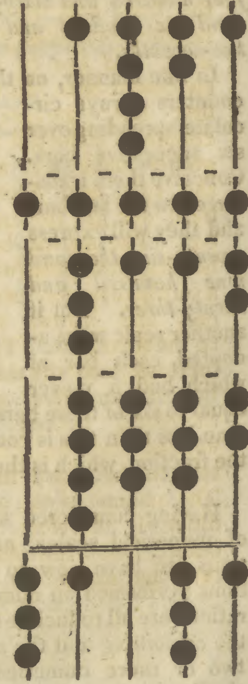
The working of this example would be simplified by employing the notation of deficient counters. Thus the several numbers are changed into other expressions as here expressed. On the first bar, the full and the open counters, being three of each kind, exactly balance each other; but, on the second bar, the full counters leave an excess of *one*. The full counters on the third bar, being eight in all, exceed the open ones by two; while, on the fourth bar, they leave a defect of one.

DENARY SCALE.



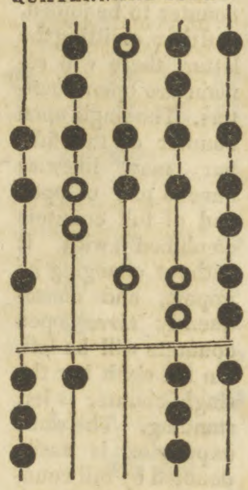
Let another example be taken of addition from numbers arranged on the *Quinary Scale*. The counters on the first bar amount to *six*, which leaves *one* counter, and furnishes *one* to the next bar. This bar now holds *eight* counters, leaving *three* consequently, and throwing *one* to the third bar. The third bar has then *ten* counters, or is left void, and gives *two* counters to the next bar. This bar, holding *eleven* counters, leaves *one*, and supplies *two* to the highest bar. The total amount of the numbers is therefore *three quadruplicate pentads*, one *triplicate pentad*, *three pentads* and *one*, or by reduction, *two thousand and sixteen*.

QUINARY SCALE.



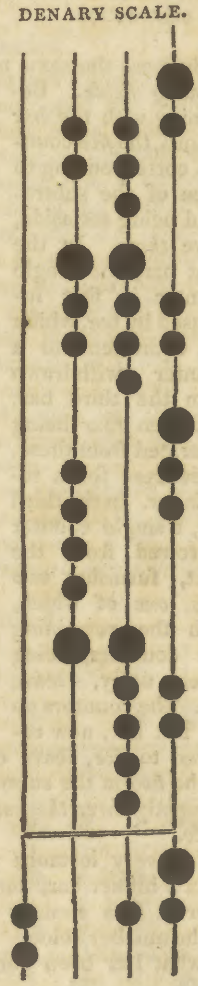
By introducing deficient counters, the process might be simplified and abridged. The first bar continues the same as before; but in the next bar, after *one* had been carried to the second bar, and joined to the full counters, there yet is an excess of *three* full counters. In thethird bar, the oppositecounters, being *two* each, are quite balanced, and leave a void; but the fourth bar yields an excess of *one* full counter, while the fifth collects *three* full counters. The result is every way the same as before.

QUATERNARY SCALE.



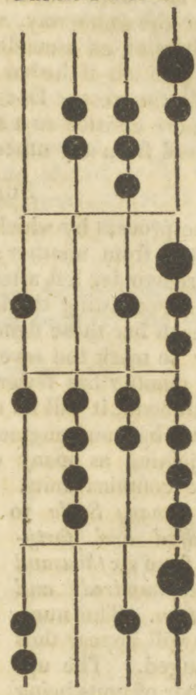
Let these numbers be transformed on the *Denary Scale*. They will stand as here expressed, occupying three bars. The first number furnishes to the successive bar *two*, *three*, and six counters; the next number gives *seven*, *eight*, *and two;* the third number delivers *four* to the third bar, passes over the second, and deposites *seven* on the first; and the last number, supplies *five*, *nine*, *and two* to the successive bars. In the first bar, the *single* counters collected together make *six*, and the two *fives* contribute *one* to the next bar. The second bar, holding four *fives* with a surplus counter, leaves *one*, and throws *two* to the next bar. This increase raises the third bar to four *fives*, and therefore, leaving it void, advances *two* counters to the fourth bar. The amount of the addition is therefore, as before, being *two thousand* and *sixteen*.

DENARY SCALE.



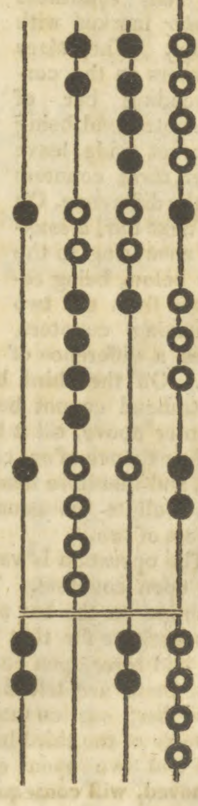
If the operation were performed in its utmost simplicity, by annexing one of the numbers always after the other, the progress of summation would be thus exhibited. The first number being actually represented by counters, the second, which is only retained in the memory, changes by its absorption the several bars, and produces *one thousand and seventeen.* To this again is joined mentally the third number, which gives *one thousand four hundred and twenty-four*, as another step in the progress. And, lastly, the fourth number, being annexed to this, completes the transformation, and produces the final result, *two thousand* and *sixteen.*

DENARY SCALE.



But, in most cases, the work of summing different numbers may be sensibly shortened, by a judicious application of open counters; which, by their intermixture, effecting in a long operation a sort of balance, will, for the most part, save the trouble of carrying to the higher bars. Whenever the full counters on a bar exceed half the index of the scale, it is preferable to substitute for them open counters. Thus, in the last example, the four numbers to be added may be denoted as here expressed. In the first bar, there is, on the whole, an excess of *four* open counters; in the second, an excess of *two* full counters; but, in the third bar, the opposite counters are exactly balanced, and leave a void. The result is consequently *two thousand and twenty*, abating *four*.

DENARY SCALE.

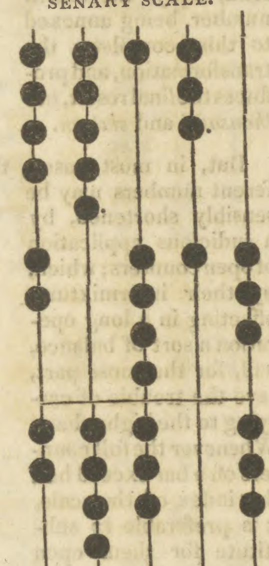


It is evident that all these operations are conducted in the same way, whether the counters occupy the bars of an ascending or of a descending series. The position of the bar of units, determines the values of all the rest. Decimal fractions, are, therefore, no more entitled to a separate discussion than those derived from any other scale.

SUBTRACTION

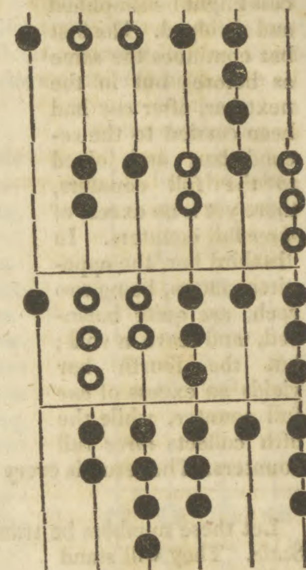
is the process by which a number is separated or extracted from another; the difference sought being the remainder left after this operation. If the counters representing the larger number, should exceed on each bar those denoting the subtrahend, we have only to mark the several excesses. But, if the upper number has fewer counters on any bar than the subtrahend, it will be necessary to take one from the higher bar, and augment the expression of the other, by joining as many counters as the index of the scale contains units. Suppose it were required on the *Senary Scale* to subtract *two thousand seven hundred and forty-five*, from *six thousand three hundred and eighteen*. The numbers will appear thus arranged. The upper bar of units being vacant, we put *six* on it, and withdraw or borrow from the next bar *an equivalent counter* marked with a dot. The *three* counters on the corresponding bar of the subtrahend, being then set aside, leave other *three* counters for the difference. On the next bar, *a counter*, answering to the one below, being removed from the two remaining counters, gives a difference of *one*. On the third bar, the *four* counters of the subtrahend cannot be taken away from the single counter above, till it has been augmented to *seven*, at the expence of *one* counter withdrawn from the next bar, and therefore marked with a dot. The fourth bar leaves all its *four* counters, and the fifth bar drops its excess of *two*.

SENARY SCALE.



The operation is varied and shortened, by adopting open counters. To take away the *three* open counters on the bar of units from the vacuity above it, substitute for that void the counterpoise of *three* full and *three* open counters, and then separating the last, there are left *three* full counters. On the second bar, *one* counter only remains. The *single* counter of the third bar may have annexed to it two full and two open counters, and the latter being removed, will consequently leave *three* full counters. On the fourth bar, conceive an open and a full counter to be joined, and then, omitting the latter, there will remain *two* open counters. The single open counter of the fifth bar may likewise have a pair of open and of full counters combined with it without changing its import, and consequently *three* open counters will be left. On the sixth bar the single counter is left standing. The same expression is easily denoted by full counters, and gives, on reduction, the number *three thousand five hundred and seventy-three*, as the result of the subtraction.

SENARY SCALE.



Suppose the same numbers were expressed on the *Denary Scale*. Beginning with the bar of units, the *five* counters corresponding to those of the subtrahend being set aside, leave *three*. In the next bar, the single counter is first increased by *ten*, which are equivalent to a counter withdrawn from the third bar, and then *four* being separated from these, gives *seven* for a remainder. In the third bar, a single counter borrowed from the next, furnishes two *fives*, *one* of which, with the remaining *two* counters, being taken away, leave *five*. The counters on the last bar, now reduced to *five*, leave only *three*, after the separation of the *two* in the subtraction. The remainder is consequently *three thousand four hundred and seventy-three*.

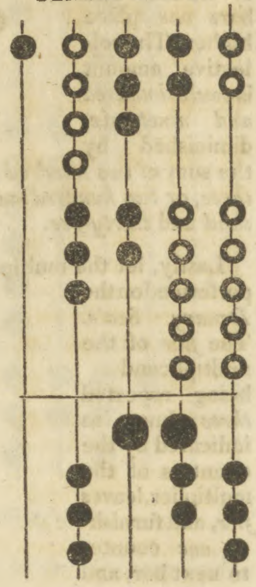
DENARY SCALE.

In every instance where a counter is borrowed from a higher bar, the effect would evidently be unaltered, if a counter were added on the same bar to the number below. This modification of the process is what has been generally termed *carrying*. It is

Palpable Arithmetic.

farther illustrated, by operating with open counters. Conceive *three* open and *three* full counters to be placed on the first bar, and the latter will be left as an excess below. On the second bar, let *five* open and *five* full counters be laid, and then, rejecting the former, there will remain *seven*. Again, annex on the third bar a *pair* of open and *another* of full counters, and *five* will be left. And, in the fourth bar, joining *three* full and *three* open counters, and next setting aside the former, there will be left *seven* open counters; which, omitting the full counter of the fourth bar, are equal to *three* full counters.

DENARY SCALE.

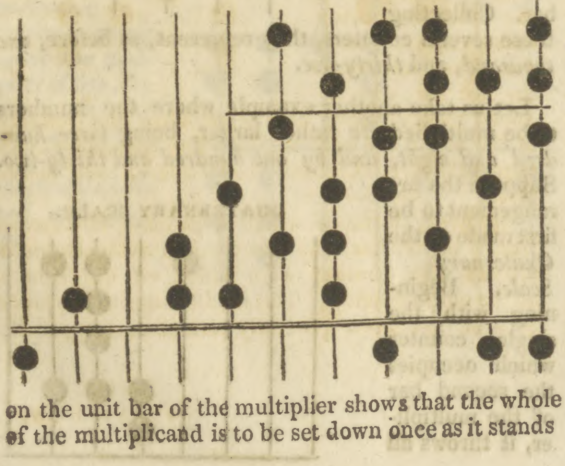


### Multiplication

is nothing but a process of repeated Addition. When the terms, however, to be multiplied are complex, and the index of the *Numerical Scale* is large, the operation will admit of being very considerably abridged. It has been already shown, that a number is virtually multiplied by the *index* of the scale, by advancing its expression *one* bar; that it is multiplied by the *second power* of that index by advancing it *two* bars; and so forth continually, according to the progressive powers. Again, if any term of the multiplier be great, it is preferable, instead of repeating the counters of the multiplicand, to collect them mentally, and only mark the result. The ready performance of multiplication depends entirely on the right application of these two principles. A few examples will elucidate the process.

Suppose it were required to multiply the number *forty-five* by *twenty-three*, that is, to add the units contained in forty-five *twenty-three* times. First, let those numbers be disposed on the *Binary Scale*. The counter

BINARY SCALE.



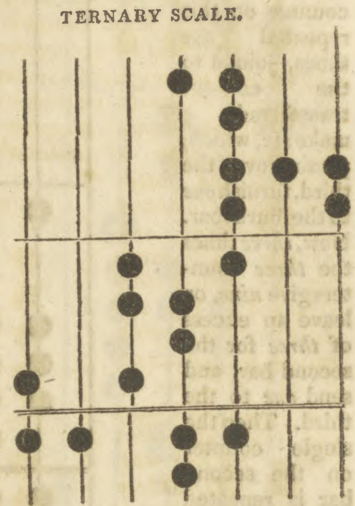
on the unit bar of the multiplier shows that the whole of the multiplicand is to be set down once as it stands

Palpable Arithmetic.

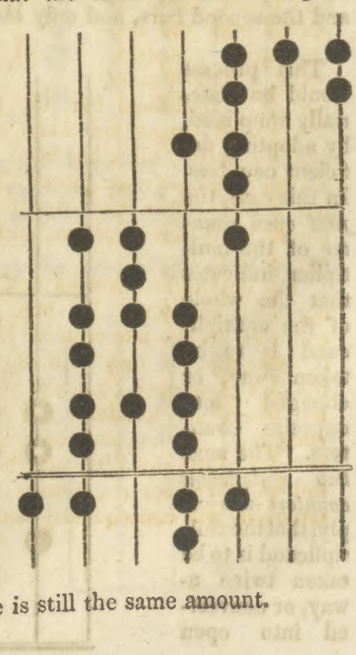
The next counter indicates, that the whole of the upper range of counters must be advanced *one* bar; the counter on the third bar intimates, that the same row should be carried *another bar* higher. The last counter, occupying the fifth bar, shows that the counters of the multiplicand should be advanced *four* bars, or that the first of them should be placed on the same bar below it. These counters, again, collected into a single row, give by reduction, *one thousand and thirty-five*.

Next, let the same numbers be arranged on the *Ternary Scale*. Following the terms of the multiplier, therefore, the multiplicand must be repeated *twice* as it stands, then *once* on a bar higher, and again *twice* on the bar above this. But twice *two* make four, leaving *one* on the third bar, and throwing *one* to the fourth bar, which produces *three*, or leaves that bar empty, and delivers *one* to the next bar. Again, the multiplicand is repeated on a bar higher, and doubled on a bar two steps higher. Collecting then the counters on each successive bar, amounting to *one* on the seventh bar, *one* on the sixth, *two* on the fourth, and *one* on the second, the result will, after being reduced, appear the same as before.

TERNARY SCALE.



It is obvious, that the units contained in *forty-five* must give the very same amount when repeated *twenty-three* times, as those in *twenty-three* after a repetition of *forty-five* times. But the interchange of multiplier and multiplicand, would, in this case, rather simplify the process. The upper counters are here advanced at once *two* bars and redoubled, and then repeated *once* on the next set of bars. Being collected, there is still the same amount.

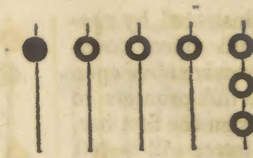


Again, suppose the same numbers to be referred to the *Senary Scale*. The three counters on the unit bar of the multiplicand being repeated *five* times, make *fifteen*, or leave *three* on that bar, and give *two* to the next. But *five* times the simple counter on the next bar, together with the *two* carried, make *seven* or leave *one*, and furnish *one* to the third bar; and the single counter on this repeated *five* times, joined to the counter transferred, make *six*, which, passing over the third, furnish *one* to the fourth bar. Now, *three* times the *three* counters give *nine*, or leave an excess of *three* for the second bar, and send *one* to the third. Then the single counter on the second bar is repeated *three* times and *one* added to it, and the next counter likewise repeated *three* times, but without addition. Collecting now the counters on the several bars, there appear *four* on the fourth, the third, and the second bars, and only *three* on the first.

SENARY SCALE.

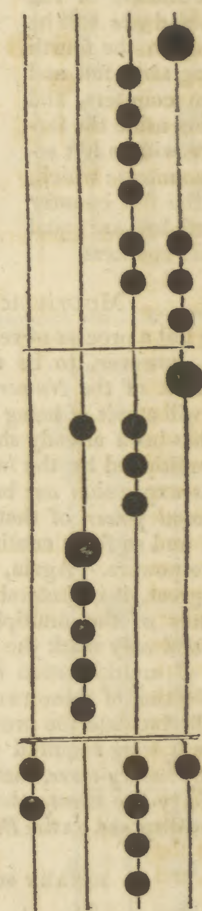
This process would be materially simplified, by adopting deficient counters. In this case, the *first open counter* of the multiplier indicates that the whole of the multiplicand is to be taken away, or changed into opposite counters. The next *two deficient counters* also imply, that the multiplicand is to be taken twice away, or converted into open

counters on the bars *one* place higher. The collective amount is *twelve hundred and ninety-six*, diminished by the sum of *two hundred and sixteen*, *thirty-six*, *six* and *three*, or *two hundred* and *sixty-one*; that is, *one thousand* and *thirty-five*.



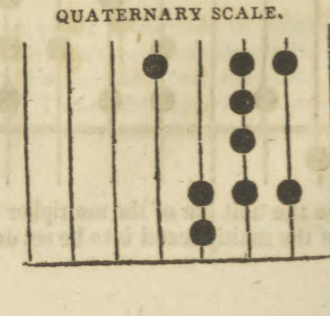
Lastly, let the multiplication of those numbers be performed on the *Denary Scale*. The *five* of the multiplicand being repeated *three* times, as indicated by the counters of the multiplier, leaves *five*, and furnishes *one* counter to next bar, and the *four* counters of the second bar being tripled, and acquiring the one carried, leave *three*, with another counter for the third bar. The *five* being next doubled by the two counters of the *second* bar of the multiplier, give *ten* for the place of the second bar, or *one* for the third; and the four counters being doubled and augmented by this transferred one, give *nine* for the third bar. Collecting these several counters, they represent, as before, *one thousand*, and *thirty-five*.

DENARY SCALE.

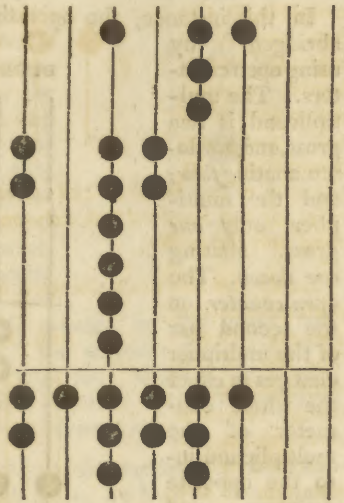


Let us take another example where the numbers to be multiplied are rather larger, being *three hundred and eight, and by one hundred and thirty-two*. Suppose the arrangement to be first made on the *Quaternary Scale*. Beginning with the single counter which occupies the second bar of the multiplier, it throws all

QUATERNARY SCALE.

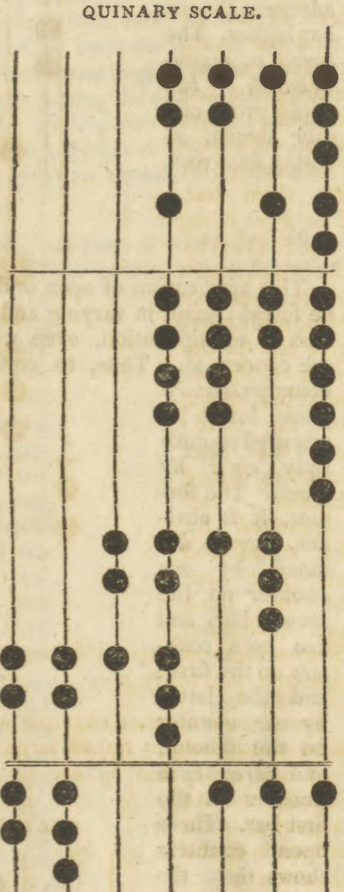


the terms of the multiplicand a bar forward, or sets the units immediately below itself. The *two* counters again, which stand on the fourth bar, redoubles all the former, and advances them *three* bars. Collecting then the counters on the several bars, and reducing their values, the result of the whole is *forty thousand, six hundred* and *fifty-six.*



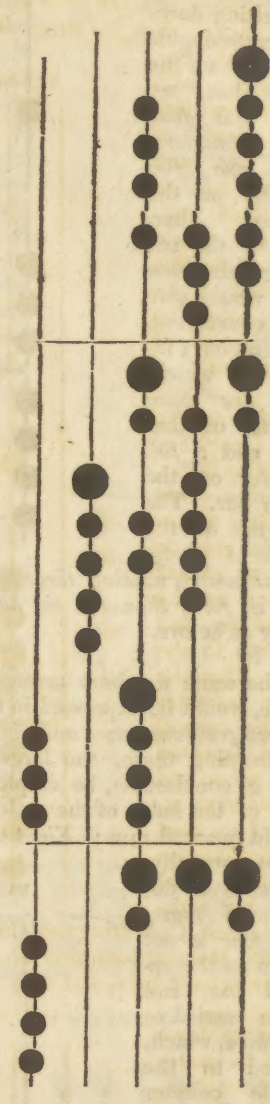
Transfer the same numbers to the *Quinary Scale,* and they will present this form. The *two* counters of the multiplier intimate, that the terms of the multiplicand are to be *doubled* in the same ranks; the single counter shows, that they are to be repeated a bar higher, and the counter on the fourth bar signifies that they are to be placed again three bars in advance. Collecting all the counters on the several bars, and condensing them by carrying higher the multiplier of five, the amount is the same as before, that is, *forty thousand six hundred and fifty-six.*

QUINARY SCALE.



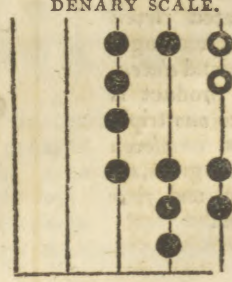
In the *Denary Scale,* more counters will be required, though a large one be adopted, for the sake of conciseness, to represent *five,* the half of the index. Beginning as usual at the right hand, the terms of the multiplicand are first *doubled* mentally, as intimated by the two counters of the multiplier; and as *twice eight* makes *sixteen,* the *six* is placed on the bar of units, and *one* carried to the next bar; then the double of *three* gives *six* counters for the third bar. Again, those terms are tripled; as signified by the counters on the second bar of the multiplier; but thrice *eight* are *twenty-four,* leaving *four* on the second bar, and throwing *two* to the third, while the triple of *three* gives *nine,* for the fourth bar. And, lastly, the whole of the multiplicand is set down *two* bars in advance. The several rows of counters being collected, give still the same result, or *forty thousand, six hundred* and *fifty-six.*

DENARY SCALE.



The operation may be somewhat abridged by employing, as circumstances will permit, open counters. Thus, instead of *eight* in the multiplicand, we may assume *ten* wanting *two,* or *one full counter* on the second bar, and *two open counters*

DENARY SCALE.



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on the first. In the first duplication, instead of setting down *six* for the double of *three* on the third bar, we may put *four open counters,* and *one full counter* on the higher bar. Again, the tripling of the same row would give *nine* counters on the fifth bar; instead of which, set *one open counter* on that bar, and a *full counter* on the sixth bar. The amount of the whole is, *forty-one thousand,* abating *three hundred and forty-four;* that is, *forty thousand six hundred and fifty-six,* exactly as before.

The same numbers arranged on the *Duodenary Scale,* would be expressed in the language of traders, by *two gross one dozen and eight,* and by *eleven dozen.* In denoting these, the large counter may, for the sake of conciseness, be employed to express *six,* the half of the index of the scale. Their multiplication would proceed thus: *Eight* counters repeated *eleven* times mentally, makes *seven* dozen and *four;* this *four* is set down on the *second* bar, and *seven* carried to the *third,* which, joined to the single counter repeated eleven times, gives a *dozen* and *six.* Having marked the *six* on the *third* bar, *one* is joined to the *two* repeated *eleven* times, making a *dozen* and *eleven.* The product is hence *one* triple gross, *eleven* double gross, *six* gross, and *four* dozen.

DUODENARY SCALE.

Palpable Arithmetic.

In this instance, the operation would be greatly abridged, by using open counters. The multiplicand is *two* gross, and *two* dozen, abating *four;* and the multiplier only *one* gross, abating *one dozen.* The *open counter* on the second bar of the multiplier changes in effect the whole character of the multiplicand into the opposite counters, and the *full counter* on the third bar repeats the same counters, and advances them a bar higher. The result is, consequently, *two* triple gross and *four* dozen, abating *five* gross.

DUODENARY SCALE

The application of open or deficient counters will be found useful, in varying and simplifying the process of multiplication, even where smaller numbers are concerned. Thus, to confine our views to the common *Denary Scale,* let it be required to multiply *eight* by *seven.* The former, it is obvious, may be denoted by *one* counter on the second bar, and *two open counters* on the first; and the latter by *one* counter on the second, and *three open counters* on the first bar. These open counters show that the terms of the upper number should be sub-

DENARY SCALE.

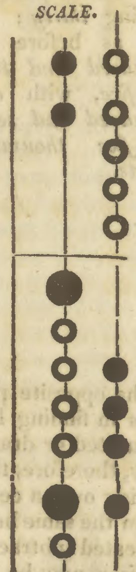
Palpable Arithmetic.

tracted *three* times; that is, repeated *thrice* with an opposite character; which gives *six full counters* for the first bar, and *three open ones* for the second. Again, the *full counter* on the second bar indicates that those terms are to be repeated unchanged, but placed one bar in advance. This combination exhibits the product. But instead of the *single counter* on the third bar, substitute *two fives* on the second; the result will then be decomposed into *five*, abating *three*, and *five* abating *two*, TENS, together with the counters *on the first bar*, or twice *three*, UNITS.

Hence the explication of the method for multiplying any numbers under ten, by help of the fingers merely; an arithmetical curiosity, very long known to mathematicians, but lately introduced, among other improvements, into the practice of the elementary schools. Beginning at the left, and proceeding to the right, *seven* fingers (including the thumbs) are counted in this example, which leave *three* fingers to close. Again, proceeding backwards from right to left, the number *eight* leaves *two* fingers, which are shut on the left hand. Then joining the projecting fingers of both hands, or *five* abating *two* and *five* abating *three*, we obtain *five tens* or *fifty*; while the product of the closed fingers, gives an accession of *six units*, making in all *fifty-six*.

As another example, suppose it were desired to multiply *nine* by *six*. These numbers may be severally expressed by *ten* abating *one*, and by *ten* abating *four*. But the *four open counters* of the multiplier, signify that the upper counters are to be changed and there repeated *four* times; while the *full counter* intimates that those counters are, without alteration, to be advanced a whole bar. Instead, however, of the single counter on the *third* bar, *two fives* may be combined with the open counters on the *second*. But this procedure can be imitated by the play of the fingers. Counting *nine* fingers, beginning with the left hand, and passing to the right, we leave *one* finger to close; and again reckoning *six*, by proceeding from the right to the left, we have *four* fingers remaining to close. If we now bring together the projecting fingers of both hands, we shall have, of TENS, *five*, abating *four*, and *five* abating *one*; that

DENARY SCALE.

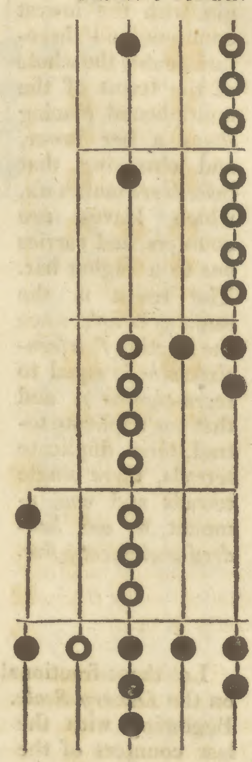


is, *fifty*, together with the product of the shut fingers, or *six* units, told *once*.

Palpable Arithmetic.

This philosophical trick cannot fail to appear striking to young practitioners, and may prove really useful, by helping to fix thoroughly and accurately in their memory the ordinary multiplication table. But the same principle can be extended farther. Suppose it were required to multiply *ninety-seven* by *ninety-six*. These numbers are merely *one hundred*, abating *three* and *four*. The product is, therefore, of *hundreds*, one hundred fold, abating *four*, and then *three*; that is, *nine thousand, three hundred*; together with *three* times *four* units, or *twelve*.

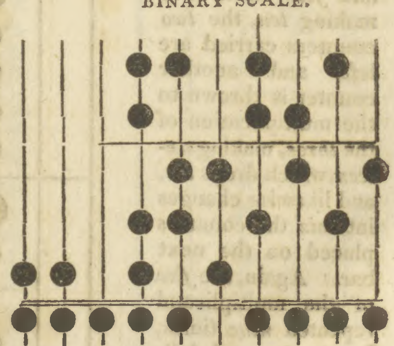
DENARY SCALE.



But instead of *seven open counters* on the third bar, the defect from ten, or *three full counters* may be placed, and an *open counter* set on the fourth bar. This result is consequently *ten thousand, three hundred and twelve*, abating *one thousand*.

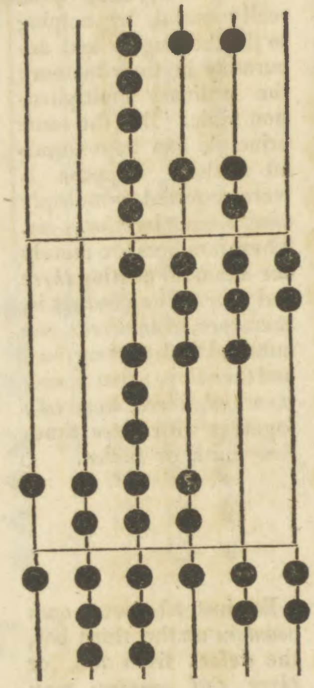
When fractions are expressed on the same numerical scale, their multiplication proceeds with equal facility as that of integers; it being only requisite to begin with the bar of units, and to descend with the lower bars. Thus, if it were sought to multiply *thirteen and a quarter*, by *nine and a half*. Let these quantities be first arranged on the *Binary Scale*, and they will stand thus: Begin therefore with the counter on the bar of units, and mark the upper row in the same ranks in which it stands; or, what must evidently give the same result, take the extreme counter which occupies the next lower bar, and depress all the counters in the row by the interval of a whole bar. Proceed in like manner with the other counters. The collective amount is *one hundred and twenty-five*, and *seven-eighths*.

BINARY SCALE.



Suppose the same fractional quantities were transferred to the *Quaternary Scale*. Instead of commencing with the bar of units, begin with the lowest counters, and therefore double the whole of the terms of the multiplicand, placing them a bar lower, and observing that *twice three* makes *six*, which leaves *two* counters, and carries *one* to a higher bar. The result is the same as before, since the fraction *fourteen-sixteenths* is equal to *seven-eighths*; and that *one* triplicate tetrad, *three* duplicate tetrads, *three* single tetrads and *one*, amount to *one hundred and twenty-five*.

QUATERNARY SCALE.



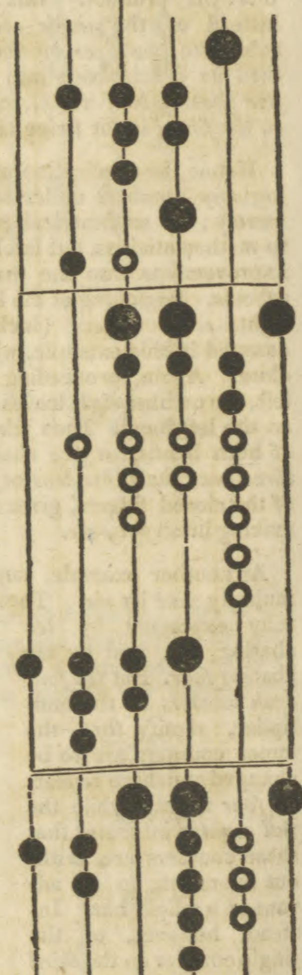
Let those fractional numbers be now represented on the *Denary Scale*. They will be thus expressed.

DENARY SCALE.

Beginning with the last counters of the multiplier, or the *five* on the bar next that of units, its product into the upper *five*, making *twenty-five*, should be placed on a bar lower. This leaves *five*, and throws *two* to the higher bar; and *five* times *two* making *ten*, the *two* counters carried are left, and another counter is thrown to the multiplication of the *three*, making *sixteen*, which drops *six*, and likewise changes into *six* the counters placed on the next bar. Again, the *five* of the multiplicand repeated *nine* times, leaves *five*, and delivers *four* to the next bar, increasing the counters on it from *eighteen* to *twenty-two*, or leaving *two* and transferring *two*. The multiplication into the *three* leaves *nine*, and gives over *two*, converting the counters on the next bar to *eleven*, or *one* counter left and *one* advanced. Collecting the counters on the different bars, we get *one hundred and twenty-five*, and *eight hundred and seventy-five thousandth parts*.

But the operation will be materially simplified, by introducing an open counter into the second term of the multiplier, as here expressed. The first step of the multiplication by *five* is the same as before; but the *open counter* on the next bar indicates, that the whole of the multiplicand is to be set down with opposite counters; and the *full counter* on the highest bar shows, that it must be repeated in advance without alteration. Collecting the counters together, and observing their mutual influence, the general result is *one hundred and twenty-five*, with *nine hundred and five thousandth parts*, abating *thirty*; that is, as before, *one hundred and twenty-five*, with *eight hundred and seventy-five thousandth parts*.

DENARY SCALE.

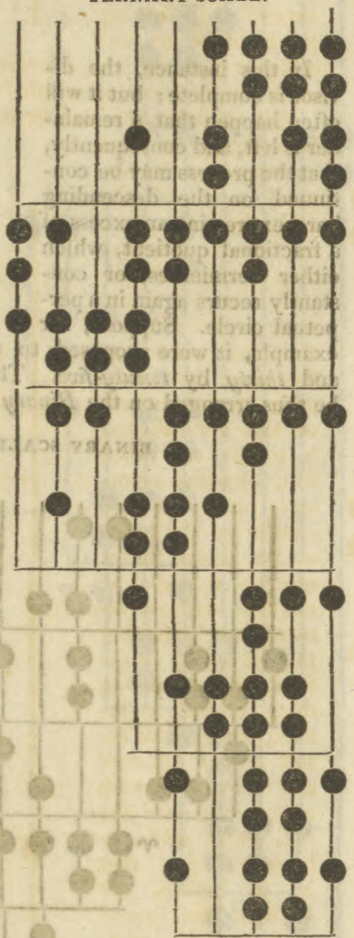


### Division

is the opposite process to Multiplication, and consists in finding how often the same number can be separated or drawn out from another. In the rudest way, therefore, this operation would be performed, by telling over a certain number of counters repeatedly from the same heap. But instead of a slow process of repeated subtraction, the number to be severed, or the *divisor*, may be first multiplied to approach the mass to be shared, or the *dividend*. The remainder can again be treated in the same manner, and the operation renewed, till nothing is left of the dividend, or a difference less than the divisor itself. Those

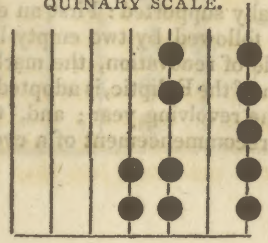
multipliers, collected together, will express the *quotient*, or the number of subtractions required to exhaust the mass. A few examples shall be taken for illustration. Suppose *sixteen thousand* and *six* were to be divided by *fifty-three*. Let these numbers be arranged first on the *Ternary Scale*, the *dividend* being lowermost, and space left for putting the *quotient* immediately under the *divisor*. Beginning at the left hand, the divisor is evidently contained *once* in the first four bars; place a counter then for the quotient, on the last of these bars; set the divisor immediately under the dividend, and note the difference, which is a counter on both the seventh and eighth bars. Of this difference, with the remaining counters brought down, four bars are less than the divisor, but it may be contained *twice* in five bars. Passing over one bar, therefore, *two* counters, joined to the quotient, are placed on the fourth bar of the range. The multiplicand is then doubled, and set down. But four bars of the remainder being less than the divisor, it may be found *once* in five bars, and consequently, omitting the third bar, *one* counter is placed on the second bar; and the remainder of the multiplicand is so great, that *two* counters may be set on the last bar; which duplication of the divisor finally exhausts the dividend. The quotient is hence *three hundred* and *two*.

TERNARY SCALE.



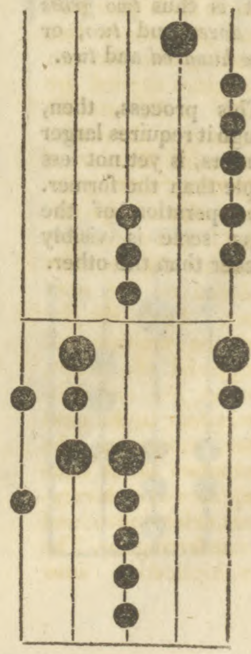
Let the same operation be performed on the *Quinary Scale*. The divisor, which here occupies three bars, is evidently not contained in the three first bars of the dividend, but it is contained *twice* in four of those bars. *Two* counters, representing this quotient, are therefore set down on the last of those bars, and the counters of the divisor, being doubled, are placed under the higher terms of the dividend. The remainder on three bars, being four and two counters, again contain the divisor *twice* on a lower bar. The double of the divisor being subtracted, the residue, or four counters, is not divisible, without including likewise the two lowest bars, when it gives *two* for the rest of the quotient. The divisor being now doubled, equals the remainder exactly.

QUINARY SCALE.



The operation will be shorter on the *Denary Scale*. The divisor, consisting of *five* counters on the second bar and *three* on the first, which includes a counter on the fifth and fourth, and six on the first, is contained *thrice* in the three first bars of the dividend. On the third bar, therefore, place *three* counters. The divisor being then tripled, leaves a remainder of one counter, which, being extended, the last bar becomes again divisible, yielding

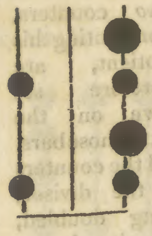
DENARY SCALE.



Palpable Arithmetic.

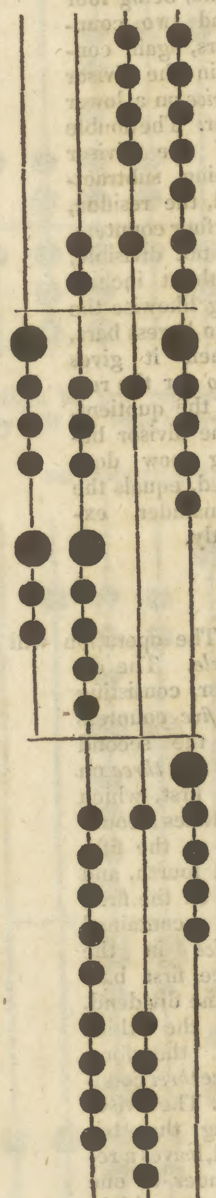
*two*, as the residuary part of the quotient.

The quotient is thus *three hundred* and *two*, the same as before.



Suppose the division were to be performed on the *Duodenary Scale*. Transferred to that scale, the divisor would, in the mercantile phrase, be called *four dozen* and *five*, and the dividend *nine double gross, three gross, one dozen* and *ten*. In the two first bars of this number, the divisor is evidently contained *twice;* therefore, *two* counters are set down on the *third* bar, and the divisor *doubled* and subtracted, leaving a remainder of *five gross, one dozen and ten*. *Two* bars of this again, contains the divisor *once;* and *one* counter, to denote it, being placed on the second bar, the subtraction is made, giving a remainder of *eight dozen and ten*, exactly double of the divisor, and consequently marked by *two* counters. The quotient is thus *two gross one dozen* and *two*, or *three hundred* and *two*.

DUODENARY SCALE.

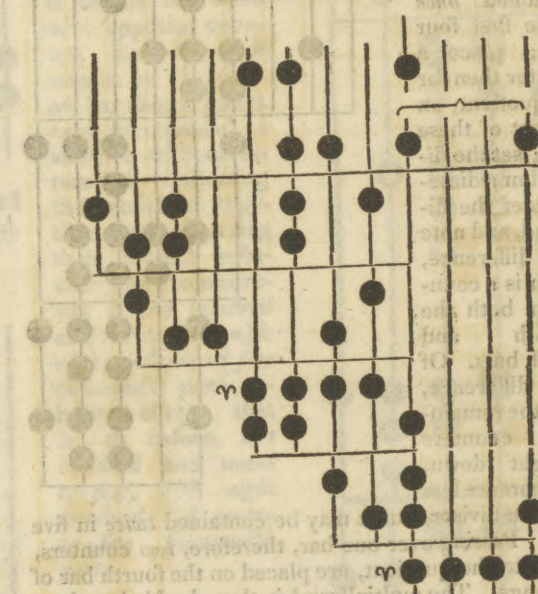


This process, then, though it requires larger counters, is yet not less simple than the former. The operation of the larger scale is visibly quicker than the other.

Palpable Arithmetic.

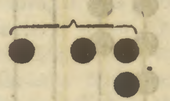
In this instance, the divisor is complete; but it will often happen that a remainder is left, and consequently, that the process may be continued on the descending bars, expressing an excess of a fractional quotient, which either terminates, or constantly recurs again in a perpetual circle. Suppose, for example, it were proposed to divide *three hundred* and *thirty* by *twenty-five*. These numbers would be thus arranged on the *Binary Scale:*

BINARY SCALE.



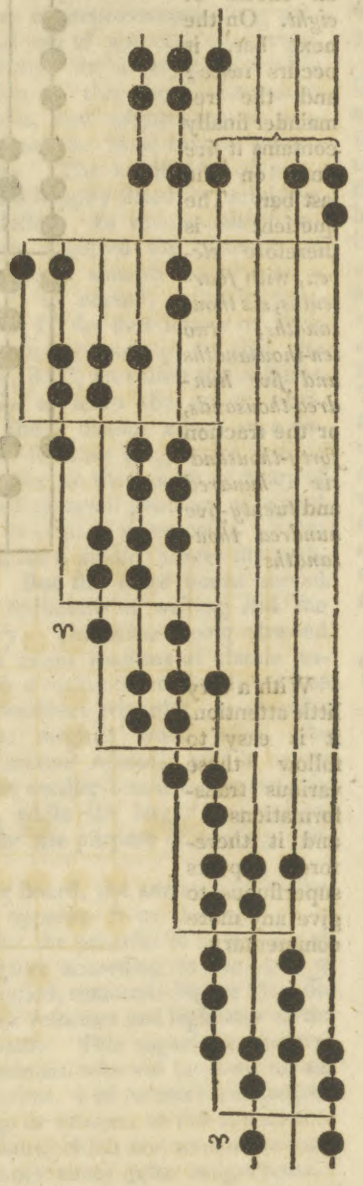
Under the fourth bar, the divisor is contained *once*, leaving a counter on the eighth and one on the second bar. Under the third bar, it is again found *once*, with the remainder of four consecutive counters. Passing over the second bar, the divisor is contained *once* under the first; but not again till after an interval of two bars, when there is left, as under the second bar, four consecutive counters. At this point, therefore, a circulation must take place, since the third bar below that of units, thus corresponds to the next above it. The same sequence will be continually supported: First an empty bar, then a counter, followed by two empty bars.—To indicate this circle of renovation, the mark ♈ for *Aries*, the first Sign of the Ecliptic, is adopted, as intimating the birth of the revolving year; and, therefore, by extension, the recommencement of a cycle.

Let the division be now performed on the *Ternary Scale*. Under the third bar, the divisor is evidently contained *once;* and *once* again successively under the second and the first bar. But the remainder is now so small, that the divisor must be depressed to the second bar below that of units, to be found in it. On the next bar lower, it is contained *twice*, with the remainder of a counter, a blank, and again a counter; the same as what occurred under the second bar. Here the circulation commences, and forms this perpetual series



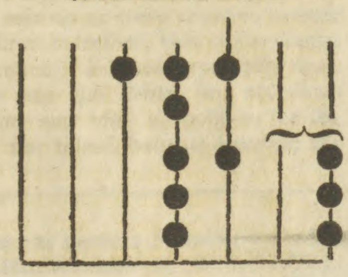
The symbol ♈ is placed to denote the alternate counters ● ● which intimate the commencement of the sequence.

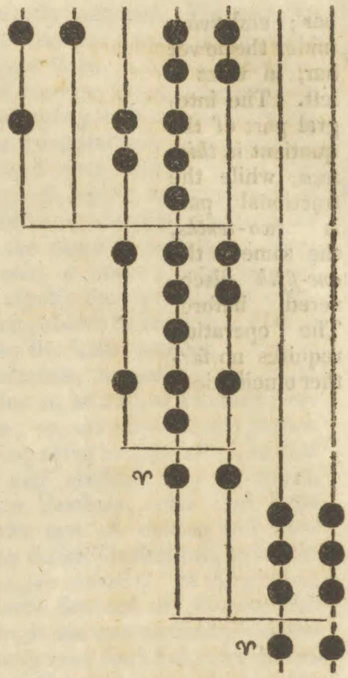
TERNARY SCALE.



Suppose the numbers *twenty-five and three hundred and thirty*, were now arranged on the *Quaternary Scale*. The divisor is contained *thrice* in the dividend, under the *second* bar, and *once* again below the place of units in the remainder. After this division, there is left only *two* consecutive counters, noted by the sign ♈, in which the divisor, at the interval of *two* bars, is contained *three* times, with the same remainder. It is evident, therefore, that the fractional part of the quotient will be afterwards continually repeated, being exhibited by a column of *three* counters alternating with *a vacant bar.*

QUATERNARY SCALE.



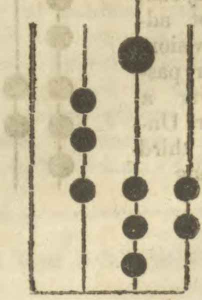


On the *Quinary Scale*, this example of division becomes almost intuitive. The divisor being here expressed by a single counter on the *third* bar, the quotient must evidently be the same as the dividend, only thrown *two* bars lower. The result of the division is consequently *thirteen* and a *fifth.*

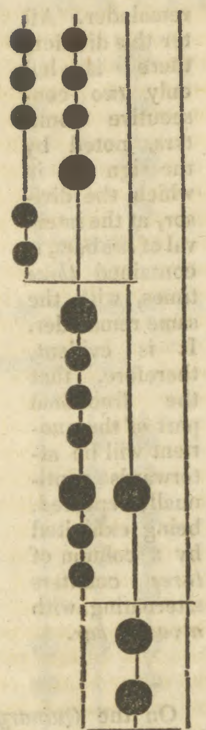
QUINARY SCALE.

Lastly, let the operation be performed on the *Denary Scale.* The divisor *twenty-five* is obviously contained *once* under the bar of *tens;* in the remainder, it is contained *three* times, under the next

DENARY SCALE.



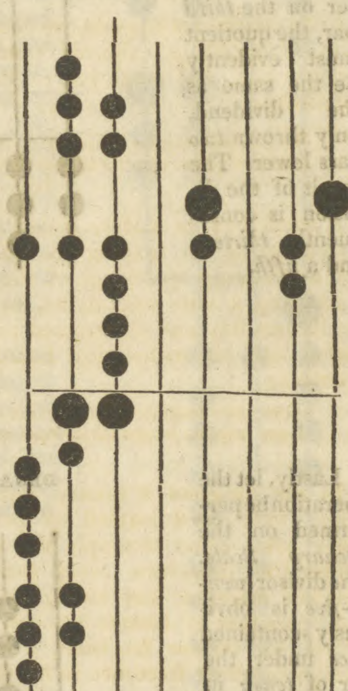
bar; and *twice*, under the lower bar, in what is left. The integral part of the quotient is *thirteen*, while the fractional part is *two-tenths*, the same as the *one-fifth* discovered before. The operation requires no farther elucidation.



bar, the divisor is found *six* times, with an excess of *eight*. On the next bar, it occurs *twice*; and the remainder finally contains it *five* times on the last bar. The quotient is therefore *eleven*, with *four-tenths*, *six thousandths*, *two ten-thousandths* and *five hundred-thousands*, or the fraction *forty-thousand six hundred* and *twenty-five hundred thousandths*.

Another example shall conclude this part of the subject. Let it be required to find the quotient of *three hundred* and *sixty-five* by *thirty-two*. And to avoid prolixity, we may confine it to the *Denary Scale*. Under the bar of *tens*, the divisor is evidently contained *once*, and in the remainder *once* again below the units. Under the next bar, it occurs *four* times; after which, the remainder, being only *two*, does not admit of division, till after passing over a whole bar. Under the third descending

DENARY SCALE.



With a very little attention, it is easy to follow these various transformations; and it therefore appears superfluous to give any more commentary.

Palpable Arithmetic.

Such is the natural process of analysing numbers, and of variously combining and separating them; and such are by consequence the simpler modes of abridging the labour of computation. Palpable arithmetic has, in the course of improvement, long preceded the invention and use of numeral characters. It was retained in Europe for a very considerable time after the adoption of this more convenient and powerful instrument, and might even at present be employed in practice to a certain extent with obvious advantage. The exhibition of numbers by counters appears happily fitted for unfolding the principles of calculation. In the schools of ancient Greece, the boys acquired the elements of knowledge by working on a smooth board with a narrow rim,—the *Abax;* so named, evidently from the combination of A, B, Γ, the first letters of their alphabet, resembling, except perhaps in size, the tablet likewise called A, B, C, on which the children with us used to begin to learn the art of reading. The pupils, in those distant ages, were instructed to compute, by forming progressive rows of counters, which, according to the wealth or fancy of the individual, consisted of small pebbles, of round bits of bone or ivory, or even of silver coins. From ψηφος, the Greek word for a *pebble*, comes the verb, ψηφιζεῖν, to *compute*. But the same board served also for teaching the rudiments of writing and the principles of Geometry. The *Abax* being strewed with green sand, the *pulvis eruditus* of classic authors, it was easy, with a *radius* or small rod, to trace letters, draw lines, construct triangles, or describe circles.—Besides, the original word Αβαξ, the Greeks had the diminutive Αβακιον; and it seems very probable, that this smaller board was commonly used for calculations, while the larger one was reserved among them for the purpose of tracing geometrical diagrams.

Grecian Abacus.

To their calculating board, the ancients make frequent allusions. It appears, from the relation of Diogenes Laërtius, that the practice of bestowing on pebbles an artificial value according to the rank or place which they occupied, remounts higher than the age of Solon, the great reformer and legislator of the Athenian commonwealth. This sagacious observer and disinterested statesman, who was however no admirer of regal government, used to compare the passive ministers of kings or tyrants, to the counters or pebbles of arithmeticians, which are sometimes most important, and at other times quite insignificant.* Æschines, in his oration for the Crown, speaking of balanced accounts, says, that *the pebbles were cleared away, and none left.*† His rival, Demosthenes, repeating his expression, employs farther the verb ἀνλανελεῖν, which means *to take up as many counters as were laid down*. It is evident, therefore, that the ancients, in keeping their accounts, did not separately draw together the credits and the debts, but set down pebbles for the former, and took up pebbles for the latter. As soon as the board became cleared, the opposite claims were exactly balanced. We may observe, that the phrase *to clear one's scores or accounts*, meaning to settle or adjust them, is still preserved in the popular language of Europe, being suggested by the same practice of reckoning with counters, which prevailed indeed until a comparatively late period.

Roman Abacus.

The Romans borrowed their *Abacus* from the Greeks, and never aspired higher in the pursuit of science. To each pebble or counter required for that board, they gave the name of *calculus*, a diminutive formed from *calx, a stone;* and applied the verb *calculare*, to signify the operation of combining or separating such pebbles or counters. Hence innumerable allusions by the Latin authors. *Ponere calculum—subducere calculum, to put down a counter*, or *to take it up;* that is, to add or subtract; *vocare aliquid ad calculum, ut par sit ratio acceptorum et datorum—to submit any thing to calculation, so that the balance of debtor and creditor may be struck.* The Emperor, Helvius Pertinax, who had been taught, while a boy, the arts of writing and casting accounts, is said, by Julius Capitolinus, to be *litteris elementariis et calculo imbutus.* St Angustine, whose juvenile years were devoted to pleasure and dissipation, acquaints us, in his extraordinary Confessions, that to him no song ever sounded more odious than the repetition or *cantio*, that *one* and *one* make *two*, and *two* and *two* make *four*. The use of the *Abacus*, called sometimes likewise the *Mensa Pythagorica*, formed an essential part of the education of every noble Roman youth:

> Nec qui *abaco numeros, et secto in pulvere metas*
> Scit risisse vafer. ——— *Pers.* Sat. i. 132.

From Martianus Capella, we learn that, as refinement advanced, a coloured sand, generally of a greenish hue, was employed to strew the surface of the *abacus*.

> Sic *abacum* perstare jubet, sic *tegmine glauco*
> Pandere pulvereum formarnm ductibus æquor.
> Lib. vii. *De Arithmetica.*

A small box or coffer, called a *Loculus*, having compartments for holding the *calculi* or counters, was a necessary appendage of the *abacus*. Instead of carrying a slate and satchel, as in modern times, the Roman boy was accustomed to trudge to school, loaded with his arithmetical board, and his box of counters:

> Quo pueri magnis e centurionibus orti,
> *Lævo suspensi loculos tabulamque lacerto.*
> *Horat.* Sat. i. 8.

In the progress of luxury, *tali* or dies made of ivory, were used instead of pebbles, and small silver coins came to supply the place of counters. Under the Emperors, every patrician living in a spacious mansion, and indulging in all the pomp and splendour of eastern princes, generally entertained, for various functions, a numerous train of foreign slaves or freedmen in his palace. Of these,

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* Ἔλεγε δὲ τοὺς παρὰ τοις τυραννοις δυναμένους παραπλησιους εἶναι ταῖς Ψηφοις ΤΑΙΣ ΕΠΙ ΤΩΝ ΛΟΓΙΣΜΩΝ καὶ γαρ εκεινων εκάστην πότὲ μὲν ΠΛΕΙΩ σημαίνειν, πότε δε ἩΤΤΩ. *Diog. Lært.* in vitâ Solonis.

† Κᾂν καθαραὶ ὦσιν ἁι Ψῆφοι και μηδὲν περιῇ. *Demosthenes* pro Corona.

the *librarius* or *miniculator*, was employed in teaching the children their letters; but the *notarius* registered expences, the *rationarius* adjusted and settled accounts, and the *tabularius* or *calculator*, working with his counters and board, performed what computations might be required. Sometimes these laborious combiners of numbers were termed reproachfully *canculones* or *calculones*. In the fervour of operation, their gestures must often have appeared constrained and risible.

> *Computat, ac cevet.* Ponatur calculus adsint
> Cum tabulâ pueri.—
> *Juv.* Sat. ix. 40.

The nicety acquired in calculation by the Roman youth, was not quite agreeable to the careless and easy temper of Horace.

> Romani pueri *longis rationibus* assem,
> Discunt in parteis centum diducere: dicat
> Filius Albini, si de quincunce remota est
> Uncia, quid superat? poteras dixisse Triens heu.
> Rem poteris servare tuam, redit uncia, quid fit?
> Semis.———
> Epist. *ad Pisonem.*

It was a practice among the ancients to keep a diary, by marking their fortunate days by a *lapillus*, or small white pebble, and their days of misfortune by a black one. Hence the frequent allusions which occur in the Classics:

> O! diem lætum, notandumque mihi *candidissimo calculo.*
> Plin. *Epist.* vi. 11.

> ——— diesque nobis
> Signanda *melioribus lapillis*——
> Mart. ix. 53.

> Hunc, Macrini, diem numera *meliore lapillo,*
> Qui tibi labentes apponit candidus annos.
> Pers. *Sat.* ii. 1, 2.

To facilitate the working by counters, the construction of the *abacus* was afterwards improved. Instead of the perpendicular lines or bars, the board had its surface divided by sets of parallel grooves, by stretched wires, or even by successive rows of holes. It was easy to move small counters in the grooves, to slide perforated beads along the wires, or to stick large knobs or round-headed nails in the different holes. To diminish the number of marks required, every column was surmounted by a shorter one, wherein each counter had the same value as five of the ordinary kind, being half the index of the Denary Scale. The *abacus*, instead of wood, was often, for the sake of convenience and durability, made of metal, frequently brass, and sometimes silver. In Plate XXVII. we have copied, from the third volume of the Supplement added by Polenus to the immense Thesaurus of Grævius, two varieties of this instrument, as used by the Romans. They both rest on good authorities, having been delineated from antique monuments,—the first kind by Ursinus, and the second by Marcus Velserus. In the one, the numbers are represented by flatish perforated beads, ranged on parallel wires; and, in the other, they are signified by small round counters moving in parallel grooves. These instruments contain each seven capital bars, expressing in order *units, tens, hundreds, thousands, ten thousands, hundred thousands*, and *millions;* and above them are shorter bars following the same progression, but having five times the relative value. With *four* beads on each of the long wires, and *one* bead on every corresponding short wire, it is evident that any number could be expressed, as far as *ten millions*.

In all these, the *Denary Scale* is followed uniformly; but there is, besides, a small appendage to the arrangement founded on the *Duodenary System*. Immediately below the place of units, is added a bar, with its corresponding branch, both marked Θ, being designed to signify *ounces*, or the twelfth parts of a pound. *Five* beads on the long wire, and *one* bead on the short wire, equivalent now to *six*, would therefore denote *eleven* ounces. To express the simpler fractions of an ounce, three very short bars are annexed behind the rest; a bead on the one marked S or Ʒ, the contraction for *Semissis*, denoting *half-an-ounce;* a bead on the other, which is marked by the inverted Ɔ. the contraction for *Sicilicum*, signifying the *quarter of an ounce;* and a bead on the last very short bar, marked Ƨ, a contraction for the symbol ϟ or *Binæ Sextulæ*, intimating a *duella* or *two-sixths*, that is, *the third part of an ounce.* The second form of the *abacus* differs in no essential respect from the first, the grooves only supplying the place of parallel wires.

We should observe that the Romans applied the same word *abacus*, to signify an article of luxurious furniture, resembling in shape the arithmetical board, but often highly ornamental, and destined for a very different purpose,—the relaxation and the amusement of the opulent. It was used in a game apparently similar to that of chess, which displayed a lively image of the struggles and vicissitudes of war. The infamous and abandoned Nero took particular delight in this sort of play, and drove along the surface of the abacus with a beautiful *quadriga*, or chariot of ivory.

The civil arts of Rome were communicated to other nations by the tide of victory, and maintained through the vigour and firmness of her imperial sway. But the simpler and more useful improvements survived the wreck of empire, among the various people again restored by fortune to their barbarous independence. In all transactions wherein money was concerned, it was found convenient to follow the procedure of the Abacus, in representing numbers by counters placed in parallel rows. During the middle-ages, it became the usual practice over Europe for merchants, auditors of accounts, or judges appointed to decide in matters of revenue, to appear on a covered *bank* or *bench*, so called, from an old Saxon or Franconian word, signifying a *seat.* Hence those terms were appropriated to offices for receiving pledges, chambers for the accommodation of money-dealers, or courts for the trying of questions respecting property or the claims of the Crown. Hence also the word *bankrupt*, which occurs in all the dialects of Europe. The term *scaccarium*, from which was derived the French, and thence the English, name for the *Exchequer*, anciently signified merely a *chess-board*, being formed from *scaccum*, denoting one of the moveable pieces in that intricate game. The reason of this application of the term is

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sufficiently obvious. The table for accounts was, to facilitate the calculations, always covered with a cloth, resembling the surface of the *scaccarium or abacus*, and distinguished by perpendicular and *chequered* lines. The learned Skene was therefore mistaken in supposing that the Exchequer derived its name from the play of chess, because its suitors appear to fight a keen and dubious battle. *

Exchequer Board, and other Contrivances.

The Court of Exchequer, which takes cognizance of all questions of revenue, was introduced into England by the Norman conquest. Richard Fitz-Nigel, in a treatise or dialogue on the subject, written about the middle of the twelfth century, says that the *scaccarium* was a quadrangular table about ten feet long and five feet broad, with a ledge or border about four inches high, to prevent any thing from rolling over, and was surrounded on all sides by seats for the judges, the tellers, and other officers. It was covered every year, after the term of Easter, with fresh black cloth, divided by perpendicular white lines, or distinctures, at intervals of about a foot or a palm, and again parted by similar transverse lines. In reckoning, they proceeded, he says, according to the rules of arithmetic, † using small coins for counters. The lowest bar exhibited *pence*, the one above it *shillings*, the next *pounds ;* and the higher bars denoted successively *tens, twenties, hundreds, thousands*, and *ten thousands* of pounds; though, in those early times of penury and severe economy, it very seldom happened that so large a sum as the last ever came to be reckoned. The first bar, therefore, advanced by *dozens*, the second and third by *scores*, and the rest of the stock of bars by the multiples of *ten*. The teller sat about the middle of the table; on his right hand, *eleven* pennies were heaped on the first bar, and a pile of *nineteen* shillings on the second; while a quantity of pounds was collected opposite to him, on the third bar. For the sake of expedition, he might employ a different mark to represent half the value of any bar, a silver penny for ten shillings, and a gold penny for ten pounds.

In early times, a chequered board, the emblem of calculation, was hung out, to indicate an office for changing money. It was afterwards adopted as the sign of an inn or *hostelry*, where victuals were sold, or strangers lodged and entertained. We may perceive traces of that ancient practice existing even at present. It is customary in London, and in some provincial towns, to have a chequer, diced with red and white, painted against the sides of the door of a chop-house.

The use of the smaller *abacus* in assisting numerical computation was not unknown during the middle ages. In England, however, it appears to have scarcely entered into actual practice, being mostly confined to those "slender clerks" who, in such a benighted period, passed for men of science and learning. The calculator was styled, in correct Latinity, *abacista ;* but, in the Italian dialect, *abbachista*, or *abbachiere*. A different name came afterwards to be imposed. The Arabians, who, under the appellation of Saracens or Moors, conquered Spain, and enriched that insulated country by commendable industry and skill, had likewise introduced their mathematical science. Having adopted a most refined species of numeration, to which they gave the barbarous name of *algarismus, algorismus*, or *algorithmus*, from the definite article *al*, and the Greek word ἀριθμος, or *number*, this compound term was adopted by the Christians of the West, in their admiration of superior skill, to signify calculation in general, long before the peculiar mode had become known and practised among them. The term *algarism* was corrupted in English into *augrim* or *awgrym*, as printed by Wynkyn de Worde, at the end of the fifteenth century; and applied even to the pebbles or counters used in ordinary calculation. In confirmation of this remark, we shall not scruple to quote a passage from our ancient poet Chaucer, who flourished about a century before, and whose verses, however rude, are sometimes highly graphic.

> "This clerk was cleped hendy Nicholas;
> Of derne love he coude and of solas;
> And therto he was slie and ful prive,
> And like a maiden meke for to se.
> A chambre had he in that hostelrie,
> Alone withouten any compagnie,
> Full fetisly ydight with herbes sote,
> And he himself was swete as is the rote
> Of licoris, or any setewale.
> His almageste and bokes grete and smale,
> His astrelabre, longing for his art,
> *His augrim-stones, layen faire apart*
> *On shelves couched at his beddes hed,*
> His presse ycovered with a falding red.
> And all about there lay a gay sautrie,
> On which he made on nightes melodie
> So swetely, that all the chambre rong.
> And *Angelus ad verginem* he song,
> And after that he song the kinge's note;
> Ful often blessed was his mery throte.
>
> *Miller's Tale*, v. 13—36.

The *abacus*, with its store of counters, wanted the valuable property of being portable, and was at all times evidently a clumsy and most incommodious implement of calculation. In many cases, it became quite indispensable to adopt some sure and ready method of expressing at least the lower numbers. The ancients employed the variously combined inflexions of the fingers on both hands to signify the numerical series, and on this narrow basis they framed a system of considerable extent. In allusion to the very ancient practice of numbering by the arbitrary play of the fingers, Orontes, the son-in-law of Artaxerxes, having incurred the weighty displeasure of that monarch, is reported by Plutarch to have exclaimed in

Digital Numeration.

* "Because mony persons conveenis in the Checker to playe their causes, contrare uthers, as gif they were fechtand in an arrayed battell, quilk is the forme and ordour of the said playe." *Skene*, ad. voc. *Scaccarium*.

† He calls it *Arismetica :* In the *Myrrour of the Worlde*, printed by Caxton, in 1481, it is strangely named *Ars Metrike*, a proof of the total ignorance of Greek at that period in England.

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terms exactly of the same import as those before ascribed to Solon, that "the favourites of kings resemble the fingers of the arithmetician, being sometimes at the top and sometimes at the bottom of the scale, and are equivalent at one time to ten thousand, and at another to mere units."*

Among the Romans likewise, the allusions to the mode of expressing numbers by the varied inflexion of the fingers, are very frequent. Hence the classical expressions, *computare digitis*, and *numerare per digitos;* and hence the line of Ausonius,

> "Quot ter luctatus cum pollice computat index."

In this play of the fingers great dexterity was acquired; and hence the phrase which so frequently occurs in the Classics—*micare digitis*. It was customary to begin with the left hand, and thence proceed to the right hand, on which the different combined inflexions indicated exactly one hundred times more. Hence the peculiar force of this passage from Juvenal:

> "Rex Pylius, magno si quicquam credis Homero,
> Exemplum vitæ fuit à cornice secundæ;
> Felix nimirum, qui tot per sæcula mortem
> Distulit, atque suos jam *dextrâ* computat annos."
> *Sat.* x. 246—250.

Many such allusions to the mode of indicating numbers by the varied position of the fingers or the hands, occur in the writings of Cicero and Quintilian. The ancients, indeed, for want of better instruments, were tempted to push that curious art to a very great extent. By a single inflexion of the fingers of the left hand, they proceeded as far as ten; and by combining another inflexion with it, they could advance to an hundred. The same signs on the right hand, being augmented, as we have seen, an hundred fold, carried them as far as ten thousand; and by a farther combination, those signs, being referred successively to different parts of the body, were again multiplied an hundred times, and therefore extended to a *million*. This kind of pantomime outlived the subversion of the Roman empire, and was particularly fitted for the slothful religious orders who fattened on its ruins, and, relinquishing every manly pursuit, recommended silence as a virtue, or enjoined it as an obligation. Our venerable Bede has explained the practice of manual numeration at some length; and, in Plate XXVII. we have given a small specimen of such inflexions and digital signs.

These signs were merely fugitive, and it became necessary to adopt other marks, of a permanent nature, for the purpose of recording numbers. But of all the contrivances adopted with this view, the rudest undoubtedly is the method of registering by *tallies*, introduced into England along with the Court of Exchequer, as another badge of the Norman conquest. These consist of straight well-seasoned sticks, of hazel or willow, so called from the French verb *tailler*, to *cut*, because they are squared at each end. The sum of money was marked on the side with notches, by the cutter of tallies, and likewise inscribed on both sides in Roman characters, by the writer of the tallies. The smallest notch signified a penny, a larger one a shilling, and one still larger a pound; but other notches, increasing successively in breadth, were made to denote ten, a hundred, and a thousand. The stick was then cleft through the middle by the deputy-chamberlains, with a knife and a mallet; the one portion being called the *tally*, or sometimes the *scachia*, *stipes*, or *kancia;* and the other portion named the *counter-tally*, or *folium*.

After the union with Scotland had been concluded in 1707, a store of hazel-rods for tallies was sent down to Edinburgh, being intended, no doubt, as a mighty refinement on the Scottish mode of keeping accounts. Their advantages, however, were not perceived or acknowledged, and they have since been suffered, we believe, to lie as so much useless lumber. But the case is very different in England, where a blind and slavish attachment to ancient forms, however ridiculous they may through time have become, is almost constantly opposed to the general progress of society. Were a sensible traveller from India or China to visit our metropolis, and report, on his return home, that a nation highly polished, enlightened, and opulent, yet keep their accounts of the public revenue, surpassing annually many millions of pounds, by means of notches cut on willow rods,—he would certainly not be credited, but supposed to use the licence of substituting a description of the practice of the most savage tribes of the American Continent.

Chinese Swan-Pan.

The Chinese have, from the remotest ages, used in all their calculations, an instrument called the *Swan-Pan*, or *Computing Table*, similar in its shape and construction to the *abacus* of the Romans, but more complete and uniform. It consists of a small oblong board surrounded by a high ledge, and parted lengthwise near the top by another ledge. It is then divided vertically, by ten smooth and slender rods of bamboo, on which are strung two small balls of ivory or bone in the upper compartment, and five such balls in the lower and larger compartment; each of the latter on the several bars denoting unit, and each of the former, for the sake of abbreviation, expressing five. See Plate XXVII., where the balls are actually set to signify the numbers annexed.

The system of measures, weights, and coins, which prevails throughout the Chinese empire, being entirely founded on the decimal subdivision, the swan-pan was admirably suited for representing it. The calculator could begin at any particular bar, and reckon with the same facility either upwards or downwards. This advantage of treating fractions exactly like integers was, in practice, of the utmost consequence. Accordingly, those arithmetical machines, but of very different sizes, are constantly used in all the shops and booths of Canton and other cities, and are said to be handled by the native traders with such rapidity and address as quite astonish the European factors.

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* Καθάπερ ὁι τῶν ἀριθμητικῶν ΔΑΚΤΥΛΟΙ νῦν μὲν ΜΥΡΙΑΔΑΣ, νῦν δε ΜΟΝΑΔΑ τιθέναι δυνανται. τὸ αὐτό καὶ τῶν βασιλέων φιλους, νῦν μεν το πᾶν δύνασθαι, νῦν δε ἐλάχιστον. Plut. *Apothegm.*

But the Chinese have also contrived a very neat and simple kind of digital signs for denoting numbers, greatly superior, both in precision and extent, to the method practised by the Romans. Since every finger has three joints, let the thumb-nail of the other hand touch those joints in succession, passing up the one side of the finger, down the middle, and again up the other side, and it will give nine different marks, applicable to the *Denary Scale* of arrangement. On the little finger, those marks signify units, on the next finger tens, on the mid-finger hundreds, on the index thousands, and on the thumb hundred thousands. With the combined positions of the joints of the one hand, therefore, it was easy to advance by signs as far as a million. To illustrate more fully this ingenious practice, we have, immediately below the *koua* of the Emperor Fou-hi, copied, in plate XXVII., from a Chinese elementary treatise of education, the figure of a hand, noted at the several joints of each finger, by characters along the inside, corresponding to *one*, *two*, and *three*, down the middle by those answering to *four*, *five*, and *six*, and again up the outside by characters expressing *seven*, *eight*, and *nine*. It is said that the merchants in China are accustomed to conclude bargains with each other by help of those signs; and that often, from selfish or fraudulent views, they conceal the pantomime from the knowledge of by-standers, by only seeming to seize the hand with a hearty grasp.

Having thus treated at sufficient length the principles and application of PALPABLE ARITHMETIC; we shall now proceed to consider the second branch of the subject, which may be denominated FIGURATE ARITHMETIC; since, to denote the range of numbers, it employs conventional symbols, or certain artificial characters disposed in a particular order, and performs, by help of these, all the ordinary operations implied in the combining and separating of numbers.

## FIGURATE ARITHMETIC

includes, first the mode of *Notation*, and next the various operations themselves which are required in compounding and resolving numbers. We shall consider these subdivisions in their order.

Invention of Numeral Characters.

NOTATION. The various attempts of men in every state of society at representing numbers, all spring from the same feeling so strongly implanted in our breasts, which unceasingly prompts them to seek the approbation and applause of their fellows. Other passions are spent in the mere support and continuance of the race; it is the love of distinction alone that elevates the human character, infuses life and action through the mass, and vigorously impels it to undertake and achieve mighty projects. The daring and restless spirit of improvement often produces much transient misery by its failures; yet, amidst all the vicissitudes which chequer and darken the tide of human affairs, it opens cheering prospects of the permanent amelioration of our species. The aspiring leader of a successful band, or the petty legislator of a rising community, is anxious to preserve the memory of the exploits he performed, or the benefits he conferred. But he is not content with obtaining the applause of his contemporaries; this fleeting existence is insufficient to fill his imagination; he looks anxiously beyond the grave, and sighs for the admiration of generations yet unborn. Hence the anxiety among all people to erect monuments of high achievements or illustrious characters. In the early periods of society, a vast mound of earth, or a huge block of stone, was the only memorial of any great event. But, after the simpler arts came to be known, efforts were made to transmit to posterity the representations of the objects themselves. Sculptures of the humblest kind occur on monumental stones in all parts of the world, sufficient to convey tolerably distinct images of the usual occupation and employments of the personages so commemorated. The next step in the progress of society was to reduce and abridge those rude sculptures, and thence form combinations of figures approaching to the hieroglyphical characters. At this epoch of improvement, the first attempts to represent numerals would be made. Instead of repeating the same objects, it was an obvious contrivance to annex to the mere individual the simpler marks of such repetition. Those marks would of necessity be suited to the nature of the materials on which they were inscribed, and the quality of the instruments employed to trace them. In the historical representations, for instance, which the Mexicans and certain Tartar hordes painted on skins, a small coloured circle, as exhibiting the original counter, shell, or pebble, was repeated to denote numbers. But, on the Egyptian Obelisks, the lower numerals, at least, are expressed by combined strokes. None but straight lines, indeed, are fitted for carving on pillars of stone, and especially for cutting on wooden posts. Curve lines were not admitted in the earliest rudiments of writing. Even after the use of hieroglyphics had been laid aside, and the artificial system of alphabetic characters adopted, the rectilineal forms were still preferred, as evidently appears in the Greek and Roman capitals, which, being originally of the lapidary sort, are much older than the small or current letters. One of the most ancient set of characters, the Runic, in which the northern languages were engraved, combines almost exclusively simple strokes at different angles.

The primary numeral traces may, therefore, be regarded as the commencement of a philosophical and universal character, drawn from nature itself, and alike intelligible to all ages and nations. They are still preserved, with very little change, in the Roman notation. Those forms, prior to the adoption of the alphabet itself, were no doubt imported by the Grecian colonies that settled in Italy, and gave rise to the Latin name and commonwealth. Assuming a perpendicular stroke I to signify *one*, another such II would express *two*, the junction of a third III *three*, and so repeatedly till the reckoner had reached *ten*. See Plate XXVII. The first class was now completed, and to intimate this, the carver threw a dash across the stroke or common unit; that is, he employed two decussating strokes X to

denote *ten*. He next repeated this mark to express *twenty*, *thirty*, and so forth, till he finished the second class of numbers. Arrived at *an hundred*, he would signify it, by joining another dash to the mark for ten, or by merely connecting three strokes thus ⊏. Again, the same spirit of invention might lead him to repeat this character, in denoting *two hundred*, *three hundred*, and so forth, till the *third* class was completed. *A thousand*, which begins the fourth class on the *Denary Scale*, was therefore expressed by four combined strokes M; and this was the utmost length to which the Romans first proceeded by direct notation.

But the division of these marks afterwards furnished characters for the intermediate numbers, and hence greatly shortened the repetition of the lower ones. Thus, having parted in the middle the two decussating strokes X denoting *ten*, either the under half Λ, or the upper half V, was employed to signify *five*. Next, the mark ⊏ for an hundred, consisting of a triple stroke, was largely divided into Γ and L, either of which represented *fifty*. Again, the four combined strokes M, which originally formed the character for *a thousand*, came afterwards, in the progress of the arts, to assume a rounded shape ↀ, frequently expressed thus CIↃ, by two disparted semicircles divided by a diameter: This last form, by abbreviation on either side, gave two portions cI and Iↄ to represent *five hundred*.

## Origin of Roman Numerals.

It was an easy process, therefore, to devise an universal character for expressing numbers. But the task was very different, to reduce the exhibition of language in general to such concise philosophical principles. This attempt seems accordingly to have been early abandoned by all nations, except the Chinese. The inestimable advantage of uniting again the whole human race, in spite of the diversity of tongues, by the same permanent system of communication, was sacrificed for the easier attainment, of representing, by artificial signs, those elementary and fugitive sounds, into which the words of each particular dialect could be resolved. Hence the ALPHABET was invented, which, notwithstanding its obvious defects, must ever be regarded as the finest and happiest effort of genius. More letters were afterwards added in succession, as the analysis of the primary sounds became extended; but the alphabet had very nearly attained its present form, at the period when the Roman commonwealth was extending its usurpation over Italy. About that epoch, a sort of reaction seems to have arisen between the artificial and the natural systems, and the numeral strokes were finally displaced by such alphabetic characters as the most resembled them. See Plate XXVII. The ancient Romans employed the letter I to represent the single stroke or mark for *one*; they selected the letter V, since it resembles the upper half of the two decussating strokes, or symbol for *five*; the letter X exactly depicted the double mark for *ten*; again, the letter L was adopted as resembling the divided symbol for *fifty*; while the entire symbol, or the tripled stroke, denoting an *hundred*, was exhibited by the hollow square ⊏, the original form of the letter C before it became rounded over. The quadrupled stroke for a *thousand* was distinctly represented by the letter M, and its variety by the compound character cIↄ, consisting of the letter I inclosed on both sides by C and by the same letter reversed; a portion of this again, or Iↄ, being condensed into the letter D, expressed *five hundred*. The letters C and M, beginning the words *Centum* and *Mille*, might have a farther claim to represent an *hundred* and a *thousand*. But the coincidence was merely accidental, since these terms migrated probably from the corresponding Greek words ἑκατον and χιλια.

This was the limit of numeration among the early Romans; but, in the progress of refinement, they repeated the symbols of a thousand to denote the higher terms of the Denary Scale. Thus, ccIↄↄ was employed to represent *ten thousand*, and cccIↄↄↄ to signify *an hundred thousand*; the letter I, inclosed between the cↄ, being, for the sake of greater distinctness, elongated. Again, each of these being divided, gives Iↄↄ for *five thousand*, and Iↄↄↄ for *fifty thousand*. These characters, however, were often modified and abbreviated in monumental inscriptions. By drawing a horizontal line over the letters, their value was augmented *one thousand times*. In the plate, so often referred to, we have endeavoured, from the best authorities, to exhibit, under the title of *Lapidary Numerals*, a complete specimen of the various contractions used by stone-cutters among the Romans. It was customary, with them, for the sake of abbreviation, to reckon, as rude tribes are apt to do, partly backwards. Thus, instead of *octodecem*, and *novemdecem*, the words for *eighteen* and *nineteen*, they frequently used *duodeviginti* and *undeviginti*, as more elegant and expressive. This practice led to the application of *deficient* numbers; an improvement scarcely to be expected from a people so little noted for invention. Instead of writing *nine*, thus VIIII, by joining *four* to *five*, they counted *one* back from *ten*, or placed I before X. In the same way, they represented *forty*, and *four hundred*, *ninety*, and *nine hundred*, by XL, and CD, XC, and CM.

Such, we have no doubt, is the real account of the rise and progress of the Roman numerals. It perfectly agrees with the few hints left us by Aulus Gellius, who expressly says, that I and X were anciently represented by one and two strokes; though Philologers, misled by partial glimpses, have indeed given a very different statement. Priscian, the Grammarian, who flourished in the reign of the Emperor Justinian, asserts, that the mark I was only borrowed from the Athenians, being adopted by them as the principal letter of the word MIA, or *one*, the M of which is considered as mute; that V or U was employed by the Romans to denote *five*, because it is the fifth vowel in the common order; that X was assumed to represent *ten*, as being the tenth consonant, and likewise following the V; that L was taken to signify *fifty*, being sometimes interchanged with N, which, as a small letter, expressed that number among the Greeks; that C was adopted to mark

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an hundred, because it is the first letter of the word *Centum;* that D, being the next letter of the alphabet, was employed to signify *five hundred;* and that M was borrowed from the Greek letter X for ΧΙΛΙΑ, or a *thousand;* only that it was rounded at the ends, to distinguish it from the symbol for ten.—But it would be idle to pursue these fanciful remarks, or to engage in serious refutation of random conjectures, which betray such a total want of general views.

After the system of Roman numerals, however, had acquired its full extent, the solicitude of superstition long preserved some traces of the rudest and most primitive mode of chronicling events. At the close of each revolving year, generally on the Ides of September, the Prætor Maximus was accustomed, with great ceremony, to drive a *nail* in the door on the right side of the temple of Jupiter, next that of Minerva, the patron of learning and the inventor of numbers. In times of public distress, when pestilence raged, and famine spread desolation abroad, the warlike, yet superstitious Romans, anxious to stay those calamities, sought to anticipate the return of the season. On such occasions, they elected a Dictator, for the sole purpose of driving the sacred nail, and beginning a more propitious year. Hence the expression of Cicero—*Ex hoc die, clavum anni movebis.*

Chinese Numerals.

As the Chinese had constructed the Swan-pan on the principles of the Roman Abacus, so they had likewise, at the remotest epoch of the Empire, framed a system of numerals, in many respects similar to those which the Romans probably derived from their Pelasgic ancestors. This will appear from the inspection of the characters engraved on Plate XXVII. It is only to be observed, that the Chinese mode of writing is the reverse of ours; and that, beginning at the top of the leaf, they descend in parallel columns to the bottom, proceeding, however, from right to left, as practised by most of the Oriental nations.

Instead of the vertical lines used by the Romans, we therefore meet with horizontal ones, in the Chinese notation. Thus, *one* is represented by a horizontal stroke, with a sort of barbed termination; *two* by a pair of such strokes; and *three* by as many parallel strokes; the mark for *four* has four strokes, with a sort of flourish; three horizontal strokes, with two vertical ones, form the mark for *five;* and the other symbols exhibit the successive strokes abbreviated, as far as *nine. Ten* is figured by a horizontal stroke, crossed with a vertical score, to show that the first rank of the Denary Scale was completed; *an hundred* is signified by two vertical scores, connected by three short horizontal lines; *a thousand* is represented by a sort of double cross; and the other ranks, ascending to *an hundred millions,* have the same marks successively compounded. Since the figures in Plate XXVII. were engraved from two elegant Chinese manuscripts, we have met with impressions of a more complete set of numerals, printed with metallic types in 1814, at Serampore, in the Elements of Chinese Grammar, by the Reverend Dr Marshman, one of the Baptist Missionaries, whose zeal, talents, enterprise, and indefatigable assiduity, in exploring the recondite dialects of the East, have reflected unfading lustre on their sect and profession. We have caused very correct *fac similes* to be taken of those characters, as represented below; in which it will be perceived, that each symbol has, for sake of distinction, a small zero or ∘ annexed to it.

| | | |
|---|---|---|
| *One,* | 一 | *Yĭh.* |
| *Two,* | 二 | *Irr.* |
| *Three,* | 三 | *San.* |
| *Four,* | 四 | *Sè.* |
| *Five,* | 五 | *Ngóo.* |
| *Six,* | 六 | *Lyeù.* |
| *Seven,* | 七 | *Ts'hīh.* |
| *Eight,* | 八 | *Păh.* |
| *Nine,* | 九 | *Kyéu.* |

| | | |
|---|---|---|
| *Ten,* | 十 | *Shĭh.* |
| *A Hundred,* | 百 | *Pŭh.* |
| *A Thousand,* | 千 | *Ts'hyen.* |
| *Ten Thousand,* | 萬 | *Wàn.* |
| *A hundred Thousand,* | 億 | *Eè.* |
| *A Million,* | 兆 | *Chaò.* |
| *Ten Millions,* | 京 | *King.* |
| *A hundred Millions,* | 垓 | *Kyai.* |

The numbers *eleven, twelve,* &c. are represented by putting the several marks for *one, two,* &c. the excesses above *ten,* immediately below its symbol. But, to denote *twenty, thirty,* &c. the marks of the multiples *two, three,* &c. are placed above the symbol for *ten.* This distinction is pursued through all the other cases. Thus, the marks for *two, three,* &c. placed over the symbols of *an hundred* or of *a thousand,* signify so many *hundreds* or *thousands.*—The character for *ten thousand,* called *wàn,* appears to have been the highest known at an early period of the Chinese history; since, in the popular language at present, it is equivalent to *all.* But the Greeks themselves had not advanced farther. In China, *wàn wàn* signifies *ten thousand* times *ten thousand,* or *an hundred millions;* though there is also a distinct character for this high number. In the Eastern strain of hyperbole, the phrase *wàn wàn,* far out-doing *a thousand years,* the measure of Spanish loyalty, is the usual shout of Long Live the Emperor! The Chinese character *chaò* for a *million,* though not of the greatest antiquity, is yet as old as the time of Confucius. The characters for *ten,* and for an *hundred, millions,* are not found in their oldest books, but occur in the Imperial Dictionary.

Such is the very complete but intricate system of Chinese numerals. It has been constantly used, from the remotest times, in all the historical, moral, and philosophical compositions of that singular people. The ordinary symbols for words, or rather things, are, in their writings, generally blended with skill among those characters. But the Chinese merchants and traders have transformed this system of notation into another, which is more concise, and better adapted for the details

Figurate Arithmetic.

of business. The changes made on the elementary characters, it will be seen, are not very material. The *one*, *two*, and *three*, are represented by perpendicular strokes; the symbols for *four* and *five* are altered; *six* is denoted by a short score above an horizontal stroke, as if to signify that *five*, the half of the index of the scale, had been counted over; *seven* and *eight* are expressed by the addition of one and two horizontal lines; and the mark for *nine* is composed of that for six, or perhaps at first a variety of five, joined to that of *four*.

| | |
|---|---|
| 〡 | *One.* |
| 〢 | *Two.* |
| 〣 | *Three.* |
| 〤 | *Four.* |
| 〥 | *Five.* |
| 〦 | *Six.* |
| 〧 | *Seven.* |
| 〨 | *Eight.* |
| 〩 | *Nine.* |

To represent *eleven*, *twelve*, &c. in this mode, a single stroke is placed on the left of the cross for ten, and the several additions of *one*, *two*, &c. annexed on the right.

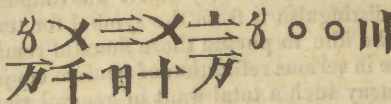
From *twenty* to *an hundred*, the signs of the multiples are prefixed to the mark for *ten*.

| | | | |
|---|---|---|---|
| 〢十 | *Twenty.* | 〢一 十 | *Twenty-one.* |
| 〣十 | *Thirty.* | 〣一 十 | *Thirty-one.* |
| 〤十 | *Forty.* | 〤一 十 | *Forty-one.* |
| 〥十 | *Fifty.* | 〥一 十 | *Fifty-one.* |
| 〧十 | *Seventy.* | 〧三 十 | *Seventy-three.* |

The same method is pursued through the hundreds, the marks of the several multiples being always placed on the left hand before the contracted symbol of *pih*, or *an hundred*. The additions are made on the right, with a small cipher or circle (o), called *ling*, when necessary, to separate the place of units. The distinction between *two hundred and three*, and five hundred and thirty, deserves to be particularly remarked.

| | | | |
|---|---|---|---|
| 〢百 | *Two hundred.* | 〢〇三 百 | *Two hundred and three.* |
| 〥百 | *Five hundred.* | 〥三 百 | *Five hundred and thirty.* |
| 〧百 | *Seven hundred.* | 〧〨〡 百 | *Seven hundred and eighty-two.* |

A similar process extends to the notation of thousands; but, for ten thousand, the character *wàn* is abbreviated. As a specimen of their combination, we select the following complex expression,



which denotes *five hundred and forty-three millions, four hundred and seventy-five thousand, and three*. The same number would be thus represented in the regular system of Chinese notation:

零萬四千五
三五十三萬
千七百四

Where the first column on the right hand presents the marks for *fifty* and *four*, with the interjacent character *wàn*, or *ten thousand*; the next column to the left has the several marks for a *thousand*, *three*, and *an hundred*; the middle column exhibits the symbols of *forty* and of *seven*; the adjacent column repeats the character *wàn*, or *ten thousand*, and then presents those for *five* and *a thousand*; and the last column has the symbol *ling*, or the *rest*, which fills up the blank, with the mark for *three*.

The last expression seems abundantly complicated, and yet it is unquestionably simpler and clearer than the corresponding notation with Roman numerals, as represented below.

IↃↃↃↃↃↃↃ · CCCCCIↃↃↃↃↃ ·
CCCCCIↃↃↃↃↃ · CCCCCIↃↃↃↃↃ ·
CCCCCIↃↃↃↃↃ · CCCCIↃↃↃↃ ·
CCCCIↃↃↃ . CCCCIↃↃↃↃ · CCCIↃↃↃ ·
CCCIↃↃↃ · CCCIↃↃↃ · CCCIↃↃↃ ·
IↃↃↃ · CCIↃↃ · CCIↃↃ · IↃↃ · III.

From such an intricate example, the imperfection of the Roman system will appear the more striking.

The abbreviated process of the Chinese traders was probably suggested by the communication with India, where the admirable system of denary notation has, from the earliest ages, been understood and practised. The adoption of a small cipher to fill the void spaces, was a most material improvement on the very complex character *ling*, used formerly for the same purpose.

About the close of the seventeenth century, the Jesuit missionaries Bouvet, Gerbillon, and others, then residing at the Court of Pekin, and able mathematicians, appear to have still farther improved the numeral sym-

bols of the Chinese traders, and reduced the whole system to a degree of simplicity and elegance of form scarcely inferior to that of our modern ciphers. With these abbreviated characters they printed, at the imperial press, Vlacq's *Tables of Logarithms*, extending to ten places of decimals, in a beautiful volume, of which a copy was presented by Father Gaubil on his return to Europe, about the year 1750, to the Royal Society of London. From this very curious work, the marks in Plate XXVII. entitled improved Chinese numerals, were carefully copied. No more than nine characters, it will be seen, are wanted, the upright cross + for ten being a mere redundancy. The marks for *one*, *two*, and *three*, consist of parallel strokes as before; an oblique cross × denotes *four*; and a sort of bisected ten signifies *five*. This symbol again, being contracted into the angular mark ∠, and combined with *one*, *two*, or *three* strokes drawn below it, represents *six*, *seven*, or *eight*; and still more abridged and annexed to the sign of four, it denotes *nine*. The distinction of units, tens, hundreds, &c. is indicated by giving the strokes alternately an horizontal and vertical position; while the blanks or vacant bars are expressed by placing small zeros.—The very important collection of logarithmic tables just mentioned, was printed by the command of the Emperor Kang-hi, a man of enlarged views, who governed China with dignity and wisdom during a long course of years. This enlightened Prince was much devoted to the learning of Europe, and is reported to have been so fond of calculation, as to have those tables abridged and printed in a smaller character, which precious volume he carried constantly fastened to his girdle. The late Emperor, Kien-long, who, after a beneficent reign of sixty years, in the decline of a protracted life, spontaneously resigned the imperial office to his son, discovered a similar taste for the Mathematical sciences.

Greek Numerals.

The Greeks, after having communicated to the founders of Rome the elements of the numeral characters, which are still preserved, again exercised their inventive genius in framing new systems of notation. Discarding the simple original strokes, they sought to draw materials of construction from their extended alphabet. They had no fewer than three different modes of proceeding. 1. The letters of the alphabet, in their natural succession, were employed to signify the smaller ordinal numbers. In this way, for instance, the books of Homer's *Iliad* and *Odyssey* are usually marked. But the practice could scarcely be older than the time of Aristotle, who, it is well known, first collected and arranged those immortal poems, in the edition of the *Casket*, for the use of his illustrious pupil Alexander the Great. 2. The first letters of the words for numerals, were adopted as abbreviated symbols. Thus, employing capitals only, I, being retained as before, to denote *one*, the letter Π of ΠΕΝΤΕ marked *five*, the Δ of ΔΕΚΑ denoted *ten*, the H of 'EKATON, anciently written HEKATON, expressed *an hundred*, the X of XIΛIA a *thousand*, and the letter M of the word MYPIA represented *ten thousand*. A simple and ingenious device was used for augmenting the powers of those symbols: a large Π placed over any letter made it signify *five thousand* times more. Thus, |Δ| denoted *fifty thousand*, and |H| *five hundred thousand*. See Plate XXVII. 3. But a mighty stride was afterwards made in numerical notation by the Greeks, when they distributed the twenty-four letters of their alphabet into three classes, corresponding to *units*, *tens*, and *hundreds*. To complete the symbols for the nine digits, an additional character was introduced in each class. The mark ς, called *episêmon*, was inserted among the units immediately after ε, the letter denoting five; and the *koppa* and *sanpi*, represented by Ϟ, ϟ, or ϡ, terminated respectively the range of *tens* and of *hundreds*, or expressed ninety and nine hundred. This arrangement of the symbols, it is obvious, could extend only to the expression of nine hundred and ninety-nine; but, by subscribing an *iota* under any character, the value was augmented a thousand fold, or by writing the letter M, or the mark for a *myriad*, or ten thousand, under it, the effect was increased ten times more. This last modification was sometimes more simply accomplished by placing two dots over the character.

Such is the beautiful system of Greek numerals, so vastly superior in clearness and simplicity to the Roman combination of strokes. It was even tolerably fitted as an instrument of calculation. Hence the Greeks early laid aside the use of the *abacus*; while the Romans, who never showed any taste for science, were confined, by the total inaptitude of their numerical symbols, to the practice of the same laborious manipulation.

It should, however, be remarked, that the Greeks distinguished the Theory from the Practice of Arithmetic, by separate names. The term *Arithmetic* itself was restricted by them to the science which treats of the nature and general properties of numbers; while the appellation *Logistic* was appropriated to the collection of rules framed to direct and facilitate the common operations of calculation. The ancient systems of Arithmetic, accordingly, from the books of Euclid, to the treatise of Böethius and the verses or commentaries of Capella, are merely speculative, and often abound with fanciful analogies. Pythagoras had brought from the East a passion for the mystical properties of numbers, under the veil of which he probably concealed some of his secret or esoteric doctrines. He regarded *Numbers* as of divine origin, the fountain of existence, and the model and archetype of all things. He divided them into a variety of different classes, to each of which were assigned distinct properties. They were prime or composite, perfect or imperfect, redundant or deficient, plane or solid; they were triangular, square, cubic, or pyramidal. *Even* numbers were held by that visionary philosopher as feminine, and allied to earth; but the *odd* numbers were considered by him as endued with masculine virtue, and partaking of the celestial nature. He esteemed the *unit*, or *monad*, as the most eminently sacred, and as the parent of all scientific numbers; he viewed *two*, or the *duad*, as the associate of the *monad*, and the mother of the elements; and he regarded *three*, or the *triad*, as perfect, being the first of the masculine numbers, comprehending the beginning, middle, and end, and hence fitted to regulate

Mystical Properties of Numbers

by its combinations the repetition of prayers and libations. As the *monad* represented the Divinity, or the Creative Power, so the *duad* was the image of Matter; and the *triad*, resulting from their mutual conjunction, became the emblem of Ideal Forms.

But the *tetrad*, or *four*, was the number which Pythagoras affected to venerate the most. It is a square, and contains within itself all the musical proportions, and exhibits by summation all the digits as far as ten, the root of the universal scale of numeration; it marks the seasons, the elements, and the successive ages of man; and it likewise represents the cardinal virtues, and the opposite vices. The ancient division of mathematical science into Arithmetic, Geometry, Astronomy, and Music, was four-fold, and the course was therefore termed a *tetractys*, or *quaternion*. Hence Dr Barrow would explain the oath familiar to the disciples of Pythagoras: "I swear by him who communicated the *Tetractys*."

*Five*, or the *pentad*, being composed of the first male and female numbers, was styled the number of the world. Repeated any how by an odd multiple, it always reappeared; and it marked the animal senses, and the zones of the globe.

*Six*, or the *hextad*, being composed of its several factors, was reckoned perfect and analogical. It was likewise valued, as indicating the sides of the cube, and as entering into the composition of other important numbers.

*Seven*, or the *heptad*, formed from the junction of the *triad* with the *tetrad*, has been celebrated in every age. Being unproductive, it was dedicated to the virgin Minerva, though possessed of a masculine character. It marked the series of the lunar phases, the number of the planets, and seemed to modify and pervade all nature.

*Eight*, or the *octad*, being the first cube that occurred, was dedicated to Cybelè, the mother of the Gods, whose image in the remotest times was only a cubical block of stone.

*Nine*, or the *ennead*, was esteemed as the square of the *triad*. It denotes the number of the Muses, and, being the last of the series of digits, and terminating the tones of music, it was inscribed to Mars.

*Ten*, or the *decad*, from the important office which it performs in numeration, was, however, the most celebrated for its properties. Having completed the cycle and begun a new series of numbers, it was aptly styled *apocatastasic* or periodic, and therefore dedicated to the double-faced Janus.

The cube of the *triad*, or the number *twenty-seven*, expressing the time of the moon's periodic revolution, was supposed to signify the power of the lunar circle. The quaternion of celestial numbers, *one, three, five*, and *seven*, joined to that of the terrestrial numbers, *two, four, six*, and *eight*, compose the number *thirty-six*, the square of the first perfect number *six*, and the symbol of the universe, distinguished by wonderful properties.

But it would be endless to recount all the visions of the Pythagorean school; nor should we descend to notice such fancies, if, by a perpetual descent, the dreams of ancient Philosophers had not, in the actual state of society, still tinctured our language, and mingled with the various institutions of civil life. Not to wander in search of illustration, we see the predeliction for the number *seven* strongly marked in the customary term of apprenticeships, in the period acquired for obtaining academical degrees, and in the legal age of majority.

Numerical Fancies of the Chinese.

The Chinese appear, from the remotest epochs of their empire, to have entertained the same admiration of the mystical properties of numbers that Pythagoras imported from the East. Distinguishing numbers into even and odd, they considered the former as terrestrial, and partaking of the feminine principle *Yang*; while they regarded the latter as of celestial extraction, and endued with the masculine principle *Yn*. The even numbers were represented by small black circles, and the odd ones by similar white circles, variously disposed and connected by straight lines. See Plate XXVII. The sum of the five even numbers, *two, four, six, eight*, and *ten*, being *thirty*, was called the number of the *Earth*; but the sum of the five odd numbers *one, three, five, seven*, and *nine*, or *twenty-five*, being the square of *five*, was styled the number of *Heaven*. The nine digits were likewise grouped in two different ways, termed the *Lo-chou*, and the *Ho-tou*. The former expression signifies the *Book of the river Lo*, or what the Great Yu saw delineated on the back of the mysterious tortoise which rose out of that river: It may be conceived from this arrangement.

| | | |
|---|---|---|
| *Four* | *Nine* | *Two* |
| *Three* | *Five* | *Seven* |
| *Eight* | *One* | *Six* |

*Nine* was reckoned the head, and *one* the tail of the tortoise; *three* and *seven* were considered as its left and right shoulders; and *four* and *two*, *eight* and *six*, were viewed as the fore and the hind feet. The number *five*, which represented the heart, was also the emblem of Heaven. We need scarcely observe, that this group of numbers is nothing but the common *magic-square*, each row of which makes up *fifteen*.

As the *Lo-chou* had the figure of a square, so the *Ho-tou* had that of a cross. It is what the Emperor Fou-hi observed on the body of the horse-dragon, which he saw spring out of the river Ho. The central number was *ten*, which, it is remarked by the commentators, terminates all the operations on numbers.

| | | | | |
|---|---|---|---|---|
| | | *Seven* | | |
| | | *Two* | | |
| *Five* | *Three* | *Ten* | *Four* | *Nine* |
| | | *Five* | | |
| | | *One* | | |
| | | *Six* | | |

Figurate Arithmetic.

The Greek system of notation proceeded directly as far as *ten thousand*, comprising four terms of the *Denary Scale;* but by subscribing M, the initial letter of μυρια, it was carried over another similar period, to signify *hundreds of millions.* But the penetrating genius of Archimedes quickly discerned the powers, and unfolded the properties of such progressions. In a curious tract, entitled ψαμμιτης or *Arenarius*, this philosopher amused himself, with showing, that it was possible, assuming the estimation of Aristarchus of Samos, and other Astronomers of that age, to represent the number of particles of sand which would be required to fill the sphere of the universe. He took the limit of the ordinary numeral system, or *ten-thousand* times *ten-thousand*, that is, an *hundred millions*, as the root of a new scale of progression, which therefore advanced eight times faster than the simple denary notation. Archimedes proposed to carry this comprehensive system as far as eight periods, which would therefore correspond to a number expressed in our mode by sixty-four digits. From the nature of a geometrical progression, he demonstrated, that proportional numbers would range at equal distances; and consequently, that the product of any two numbers must have its place determined by the sum of the separate ranks, a principle which involves the theory of logarithms.

Extended Notation proposed by Archimedes:

The fine speculation of the Sicilian philosopher does not, however, appear to have been carried into effect; and without actually performing those calculations, he contents himself by pointing out the process, and stating the approximate results. But Apollonius, the most ingenious and inventive, next to Archimedes, of all the ancient mathematicians, resumed that scheme of numeration, simplified the construction of the scale, and reduced it to a commodious practice, For greater convenience, he preferred the simple myriad as the root of the system, which, therefore, proceeded by successive periods, corresponding to four of our digits. The periods were distinguished by breaks or blanks. That most important office which, in the modern system of notation, the cipher performs, by marking the rank of the digits, was indeed unknown to the earlier Greeks. They were hence obliged, when the lower periods failed, to repeat the letters Μυ. or the contraction for μυρια, *ten thousand.* Thus, to express *thirty-four trillions*, they wrote λδ Μυ. Μυ. Μυ. To signify *units* separately, it was customary with them to prefix the mark M°. or the abbreviation for *monad.*

and by Apollonius.

The procedure of the Greek arithmetician was necessarily slower and more timid than our simple, yet refined mode of calculation. Each step in the multiplication of complex numbers appeared separate and detached; without any concentration which the moderns obtain, by carrying forward the multiples of ten, and blending together the different members of the product. In ancient Greece, the operations of arithmetic, like writing, advanced from left to right; each part of the multiplier was in succession combined with every part of the multiplicand; and the several products were distinctly noted, or, for sake of compactness, grouped and conveniently dispersed, till afterwards collected into one general amount.

Pappus of Alexandria, in his valuable *Mathematical Collections*, has preserved a set of rules which Apollonius had formed, for facilitating arithmetical operations. These are, in the cautious spirit of the ancient Geometry, branched out into no fewer than twenty-seven propositions, though all comprised in the principle formerly stated by Archimedes: *That the product of two integers of different ranks, will occupy a rank corresponding to the sum of the component orders.* Suppose μ were to be multiplied into σ, or *forty* into *two hundred:* Take the lower corresponding characters δ and β, or *four* and *two*, which were called πυθμενες or radicals, the one depressed ten times, and the other an hundred times; and multiply their product η or *eight* successively by the ten and the hundred, or at once by a thousand, and the result is ͵η or *eight thousand.*

Greek mode of Calculation.

We shall take an example in multiplication, affording more variety than such as occur in Eutocius, which generally consist in the mere squaring of numbers. Let it be required to multiply *eight hundred and sixty-two*, by *five hundred* and *twenty-three.* The operation would be performed in this way.

$$
\begin{array}{llllll}
 & & & \omega & \xi & \beta \\
 & & & \phi & \varkappa & \gamma \\
\hline
\ddot{\mu} & \ddot{\gamma} & {}_{,}\alpha & & & \\
 & \ddot{\alpha} & \varsigma & & & \\
 & & {}_{,}\alpha & \sigma & \mu & \\
 & & {}_{,}\beta & \upsilon & & \\
 & & & \rho & \pi & \varsigma \\
\hline
\ddot{\mu} & \ddot{\varepsilon} & & \omega & \varkappa & \varsigma
\end{array}
$$

In the first range, φ multiplied into ω, being the same as the product of *eight* and *five*, augmented ten thousand times, is consequently denoted by $\ddot{\mu}$ or $\overset{\mu}{\mathrm{M}}$; φ multiplied into ξ gives the same result as *five* times *six* increased a thousand fold, and therefore expressed by $\ddot{\gamma}$ or $\overset{\gamma}{\mathrm{M}}$; and φ multiplied into β, evidently makes a thousand or ͵α. In the second range, κ multiplied into ω gives the same product as *eight* repeated *twice*, and then augmented a thousand times, or denoted by $\ddot{\alpha}\varsigma$; κ multipled into ξ is equivalent to *six* repeated *twice*, and afterwards increased an hundred fold, or expressed by ͵α σ; and κ multiplied by β gives forty, the value of μ. In the third range, γ multiplied into ω produces twenty-four hundred, which is denoted by ͵β υ; γ multiplied into ξ makes an hundred and eighty, or ρ π; and

Figurate Arithmetic.

lastly, $\gamma$ multiplied into $\beta$ gives ς, the symbol for *six*. Collecting the scattered members into one sum, the result of the multiplication of *eight hundred and sixty-two* by *five hundred and twenty-three* is $\ddot{\mu}\ \epsilon\ \omega\ \kappa\ \varsigma$ or *four hundred and fifty thousand, eight hundred and fifty-six.*

But the Greek notation was not adapted for the descending scale. To express fractions, two distinct methods were followed. 1. If the numerator happened to be unit, the denominator was indicated by an accent. Thus $\delta'$ signified *one fourth*, and $\kappa\epsilon'$ one *twenty-fifth*; but *one-half* being of most frequent recurrence, was signified by a particular character, varying in its form, C, ∠, C′, or ꓘ. 2. In other cases, it was the practice of the Greeks, to write the denominator, as we do an exponent, a little above the denominator, and towards the right hand: Thus, $\beta^{\iota\alpha}$ intimated *two-elevenths*, and $\pi\alpha^{\rho\kappa\alpha}$ *eighty-one, of an hundred and twenty-one* parts.

As an illustration of the management of fractions, we select an example somewhat complicated from the commentary which Eutocius of Ascalon wrote about the third century of our æra, on the Tract of Archimedes concerning the quadrature of the circle. Let it be required to multiply the mixed number *one thousand* and *thirty-eight*, with *nine-elevenths*, by itself.

Multiplication of Fractions;

$$
\begin{array}{l}
\alpha\ \omega\ \lambda\ \eta\quad \theta^{\iota\alpha} \\
\alpha\ \omega\ \lambda\ \eta\quad \theta^{\iota\alpha} \\
\hline
\underset{M}{\rho}\ \underset{M}{\pi}\ \underset{M}{\gamma}\ \eta\ \omega\ \varsigma\ \eta\quad \beta^{\iota\alpha} \\
\pi\ \underset{M}{\xi\delta}\ \underset{M}{\beta}\ \delta\ \varsigma\ \upsilon\ \chi\ \nu\ \delta\quad \varsigma^{\iota\alpha} \\
\underset{M}{\gamma}\ \underset{M}{\beta}\ \delta\ ϡ\ \sigma\ \mu\ \kappa\ \delta\quad \varsigma^{\iota\alpha} \\
\eta\ \varsigma\ \upsilon\ \sigma\ \mu\ \zeta\ \delta\ \varsigma\quad \varsigma^{\iota\alpha} \\
\omega\ \iota\ \eta\quad \beta^{\iota\alpha} \\
\chi\ \nu\ \delta\quad \varsigma^{\iota\alpha} \\
\kappa\ \delta\quad \varsigma^{\iota\alpha} \\
\varsigma\quad \varsigma^{\iota\alpha} \\
\pi\alpha^{\rho\kappa\alpha} \\
\hline
\tau\ \underset{M}{\lambda}\ \eta\quad \alpha\ \sigma\ \nu\ \alpha\quad \zeta^{\iota\alpha}\ \pi\alpha^{\rho\kappa\alpha} \\
\text{or, } \tau\ \underset{M}{\lambda}\ \eta\quad \alpha\ \sigma\ \nu\ \beta\quad \lambda\zeta^{\rho\kappa\alpha}
\end{array}
$$

It is to be observed, that, to multiply the several integers by the fraction nine-elevenths, amounts to their multiplication by nine, and the subsequent division by eleven. The excesses being *two*, and *six-elevenths*, are denoted by $\beta^{\iota\alpha}$ and $\varsigma^{\iota\alpha}$; while the product of the fraction itself gives *eighty-one* of *an hundred and twenty-one* parts, expressed by $\pi\alpha^{\rho\kappa\alpha}$.

and of Sexagesimals.

But the laborious operations that such complex fractions required, were afterwards superseded by the use of *sexagesimals*, which we have already observed, the astronomers, and especially Ptolemy, had introduced. "The division of the circumference of the circle into three hundred and sixty equal parts or degrees, was no doubt originally founded on the supposed length of the year, which, expressed in round numbers, consists of twelve months, each composed of thirty days. The radius approaching to the sixth part of the circumference, would contain nearly sixty of those degrees; and after its ratio to the circumference was more accurately determined, the radius still continued to be distinguished into the same number of divisions, which likewise bore the same name. As calculation now aimed at greater accuracy, each of these sixty divisions of the radius was, following the uniform progression, again subdivided into sixty equal portions called minutes; and repeating the process of sexagesimal subdivision, seconds and thirds were successively formed. The operations with sexagesimal fractions were performed in the descending scale, on a principle quite similar to that which Archimedes had before laid down. Each period of the multiplier, still proceeding from the left hand, was multiplied into a period of the multiplicand; and this product was then thrown to a rank depressed as much as the descents of both its factors. Thus, minutes multiplied into seconds, produced thirds; and seconds multiplied into thirds, produced fifths." *Edinburgh Review*, xviii. p. 200.

As an exemplification of this process, we shall take the question proposed by Theon, to find the square of the side of a regular decagon inscribed in a circle, or the chord of *thirty-six* degrees, which, according to Ptolemy's computation, measured in sexagesimal parts of the radius, *thirty-seven* degrees, *four* minutes, and *fifty-five* seconds. The multiplication is thus effected:

$$
\begin{array}{lllll}
\lambda\zeta & \delta & \nu\epsilon & & \\
\lambda\zeta & \delta & \nu\epsilon & & \\
\hline
\alpha\tau\xi\theta & \rho\mu\eta & \beta\lambda\epsilon & & \\
 & \rho\mu\eta & \iota\varsigma & \sigma\kappa & \\
 & & \beta\lambda\epsilon & \sigma\kappa & \\
 & & & & \gamma\kappa\epsilon \\
\hline
\alpha\tau o\epsilon & \delta & \iota\delta & \iota & \kappa\epsilon
\end{array}
$$

Here in the first line, λζ multiplied into λζ in the place of units, gives ͵ατξθ or *thirteen hundred and sixty-nine* degrees; λζ into δ on the next bar, gives ρμη or *one hundred and forty-eight* minutes; and λζ into νε, on the lowest bar, gives ͵βλε or *two thousand and thirty-five* seconds. In the second line, δ multiplied into λζ gives the product ρμη as before; δ multiplied into δ, both of them on the bar of minutes, gives ιϛ or *sixteen* seconds; δ into νε, gives σκ, or *two hundred and twenty* thirds. Lastly, in the third line, the νε on the bar of seconds, multiplied successively into λζ and δ, produce, as before, ͵βλε and σκ on the bars of seconds and thirds; and νε, multiplied by itself, gives ͵γκε, or *three thousand and twenty-five* fourths. These several products being reduced and collected together, formed the total amount of ͵ατοε δ ιδ ι κε or *thirteen hundred and seventy-five* degrees, *four* minutes, *fourteen* seconds, *ten* thirds, and *twenty-five* fourths; but all the terms below seconds, were omitted in practice as insignificant.

This calculation is laborious and intricate; yet, with a very few terms, it approaches to a considerable degree of accuracy. One of the most elegant theorems in elementary geometry demonstrates, that the side of a regular decagon, inscribed in a circle, is equal to the segment of the radius, divided in extreme and mean ratio. Wherefore the square now computed, should be equal to the product of *sixty*, or the radius, into *twenty-two* degrees, *fifty-five* minutes, and *five* seconds, the smaller segment; that is, equal to *thirteen hundred* and *seventy-five* degrees, and *five* minutes, from which it differs only by the defect of less than one minute.

The Sexagesimal Arithmetic was, therefore, a most valuable improvement engrafted on the notation of the Greeks. The astronomers of Alexandria and Constantinople continued to employ it in all their calculations, and were afterwards imitated by succeeding observers among the Arabians and Persians. The mode of working sexagesimals had thus become generally known, and reduced to practice; but we owe the first distinct treatise on those fractions to a very extraordinary character,—Barlaam, a Calabrian monk, the friend and Greek preceptor of the famous Petrarch, and a man of learning and vigorous intellect, who laboured by his writings and his missions to reunite the Eastern to the Western church. This adventurous personage, whose wayward conduct and dark features betrayed a lurking ferocity, met with a most singular fate. Being overtaken by a tremendous thunder-storm, while crossing the Adriatic Sea, he lashed himself to the mast of the bark, and was, in this situation, struck dead by a flash of lightning. The event happened in 1348: but Barlaam's tract on sexagesimals, neatly composed in six books, after the strict manner of the Ancients, and entitled generally Λογιστικη or *Computation*, first appeared in a Latin version at Strasburg in 1572, though not published complete with the Greek text, until the year 1600, when it was edited at Paris by Chambers of Eton, from a manuscript procured from the Continent by the zeal of Sir Henry Savile.

To facilitate the operations with sexagesimals, it seemed indispensible to have a more extensive multiplication table, that should include the mutual products of all the numbers from one to sixty. This was actually constructed, about the middle of the sixteenth century, by Philip Lansberg, a Dutch Clergyman; and has been exhibited since, in various forms, by Dr Wallis and others. In the mean time, a material change had been effected in the subdivision of the radius of the circle, from which the sexagesimal system had taken its rise. Purbach, the great restorer of mathematical science, instead of making the radius to consist of 216,000 seconds, as Ptolemy and succeeding Astronomers had done, stopt short at sixty degrees, and distinguished each of these, by a repeated centesimal division, into ten thousand equal parts. Regiomontanus advanced a step farther, and rejecting the sexagesimal admixture, he divided the radius at once into a million of parts, thus following out an arrangement purely decimal. The subdivision into degrees, minutes, and seconds, was henceforth confined to the circumference itself; and when logarithms came afterwards to be adapted to those fractions, they received the appellation, once general, though now restricted, of *Logistic*. But the sexagesimal subdivision had nearly been rejected altogether. Our very meritorious countryman, Mr Briggs, in computing his large canon of logarithms, followed in another branch the example of Purbach, by distinguishing each degree of the circumference into an *hundred* minutes, and each of these again into an *hundred* seconds; and we cannot help regretting, that this easy and obvious improvement had not been generally embraced at the time it was proposed. The French Mathematicians have lately gone farther, and endeavoured to pursue, to its utmost extent, the decimal subdivision first introduced by Regiomontanus. They begin with dividing the quadrant into an *hundred*, instead of ninety, degrees; and then following the plan of Briggs, they successively divide each degree into an *hundred* minutes, and each minute into an *hundred* seconds. But the advantages which might arise from the adoption of this plan, are not sufficient perhaps to outweigh the manifest inconvenience that must attend it in the present advanced state of the science; and, notwithstanding the sanguine dreams of some of its projectors, we cannot indulge the expectation of ever seeing it obtain a general and durable currency.

"The Greek arithmetic, then, as successively moulded by the ingenuity of Archimedes, of Apollonius, and Ptolemy, had attained, on the whole, to a singular degree of perfection, and was capable, notwithstanding its cumbrous structure, of performing operations of very considerable difficulty and magnitude. The great and radical defect of the system consisted in the want of a general mark analogous to our cipher, and which, without having any value itself, should serve to ascertain the rank or power of the other characters, by filling up the vacant places in the scale of numeration. Yet were the Greeks not altogether unacquainted with the use of such a sign; for Ptolemy, in his *Almagest*, employs the small ο, to occupy the accidental blanks which occurred in the notation of sexagesimals. This letter was perhaps chosen by him, because immediately succeeding to ν, which denotes 60, it could not, in the sexagesimal arrangement, occasion any sort of ambiguity. But the advantage thence resulting was entirely confined to that particular case. The letters, being already sig-

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nificant, were generally disqualified for the purpose of a mere supplementary notation; and the selection of an alphabetic character to supply the place of the cipher may be considered as an unfortunate circumstance, which appears to have arrested the progress towards a better and more complete system. Had Apollonius classed the numerals by denary triads, instead of tetrads, he would have greatly simplified the arrangement, and avoided the confusion arising from the admixture of the punctuated letters, expressing thousands. It is by this method of proceeding with periods of three figures, or advancing at once by thousands instead of tens, that we are enabled most expeditiously to read off the largest numbers. The extent of the alphabet was favourable to the first attempts at enumeration; since, with the help of three intercalations, it furnished characters for the whole range below a thousand; but that very circumstance, in the end, proved a bar to future improvements. It would have been a most important stride, to have next exchanged those triads into monads, by discarding the letters expressive of tens and hundreds, and retaining only the first class, which, with its inserted *episêmon*, should denote the nine digits. The *iôta*, which signified ten, now losing its force, might have been employed as a convenient substitute for the cipher. By such progressive changes, the arithmetical notation of the Greeks would at last have reached its utmost perfection, and have exactly resembled our own. A wide interval, no doubt, did still remain; yet the genius of that acute people, had it continued unfettered, would in time, we may presume, have triumphantly passed the intervening boundaries. But the death of Ptolemy was succeeded by ages of languor and decline; and the spirit of discovery insensibly evaporated in miserable polemical disputes, till the fair establishment of Alexandria was finally overwhelmed under the irresistible arms of the Arabs, lately roused to victory and conquest by the enthusiasm of a new religion." (*Edinburgh Review*, Vol. XVIII. p. 203.)

History of the Denary Numerals.

The ingenuity and varied resources of the ancient Greeks were the main causes which diverted them from discovering our simple denary system. Having attained a distinct conception of the powers of the geometrical progression, and even advanced so far as to employ their small o to fill the breaks of a period, nothing seemed wanting but to dismiss the punctuated letters and those for tens and for hundreds, and to retain merely the direct symbols for units, that is, the first third part of their alphabet. Here, however, those masters of science were stopt in their career, and the Eastern Empire presents a melancholy picture of the decline and corruption of human nature. Ingenuity had degenerated into polemical subtlety, and the manly virtues which freedom inspires were exchanged for meanness and self-abasement.

Some writers, misled by very superficial views of the subject, have yet ascribed the invention of the modern numeral characters to the Greeks, or even to the Romans. Both these people, for the sake of expedition, occasionally used contractions, especially in representing the numbers and fractions of weights or measures, which, to a credulous peruser of mutilated inscriptions, or ancient blurred manuscripts, might appear to resemble the forms of our ciphers. But this resemblance is merely casual, and very far indeed from indicating the adoption of a regular denary notation. The most contracted of the Roman writings was formed by the marks attributed to Tiro or Seneca, while that of the Greeks was mixed with the symbols called *Siglæ*; both of which have exercised the patience and skill of Antiquaries and Diplomatists. In the latter species of characters, were kept the accounts of the revenues of the Empress Irene at Constantinople. But the modern Greeks appear likewise to have sometimes used a simpler kind of marks, at least for the low numbers. The continuator of Matthew Paris's *History* relates, that "in the year 1251 died John Basingstoke, Archdeacon of Leicester, who brought into England the numeral figures of the Greeks, and explained them to his friends." It is subjoined, that they consisted of a perpendicular stroke, with a short line inserted at different heights and at different angles, signifying units on the left, and tens on the right side. The figures themselves are scrawled on the margin of the text. But they are evidently so different in their form, and so distinct in their nature, from the modern ciphers, that one cannot help feeling surprise, to see an author of any discernment refer the introduction of the latter to Basingstoke.

It cannot be doubted, that we derived our knowledge of the numeral digits from the Arabians, who had themselves obtained this invaluable acquisition from their extended communication with the East. Those deserving people who, under the name of Moors or Saracens, had for many centuries cultivated Spain, were most ready to acknowledge their obligation to the natives of India, who, according to Alsephadi, a learned Arabian doctor, boasted of three very different inventions,—the composition of the *Golaila Wadamna*, or Pilpay's Fables,—the game of chess,—and the nine digital characters. Still much obscurity hangs over the whole subject. Two distinct inquiries naturally present themselves: 1. At what period did the Arabians first become acquainted with those characters; and, 2. What is the precise epoch when the knowledge of them was imparted to the Christian nations of Europe. We shall take a short review of both these questions.

Proofs of their Indian origin.

1. Gatterer, the late ingenious and very learned Professor of History at Göttingen, in his *Elements of Universal Diplomacy*, maintains that our ciphers were only primordial letters, invented by Taaut or Theut, and known to the ancient Egyptians and Phœnicians, being still distinctly observed, as he asserts, in the inscriptions painted on the coverings of the oldest mummies; and that afterwards, along with other branches of science, they passed to the Oriental nations, among whom they were preserved, till the victorious arms of the Mussulmen penetrated to India, and brought back those precious monuments of genius. But we cannot believe that a contrivance so very simple, and so eminently useful as that of the nine digits, if once communicated, could ever again be lost or neglected. Pythagoras and Boethius merely contemplated the properties of numbers, and seem not, in their calculations, to have gone beyond the use of the *Abacus*. An early intercourse had no doubt subsisted between the people of Egypt and of India, and a striking resemblance may be traced in their customs, their

buildings, and their religious rites. But the characters exhibited on the Egyptian monuments bear no indication of the *Denary System*, and are, like the Roman and Chinese numerals, abridged representations of objects, rather than arbitrary signs.

That the occupiers of Hindostan and the nations communicating with them, have for ages been acquainted with the use of the denary notation, cannot be disputed. But was this an original discovery, or at what distant epoch was it first introduced among them? The easy credulity of European visitors encouraged the Brahmins to set up very lofty pretensions respecting the antiquity of their science. Among other treasures, they boasted the possession, from time immemorial, of an elementary treatise on arithmetic and mensuration, composed in Sanscrit, and called *Lilawati*, of such inestimable value as to be ascribed to the immediate inspiration of Heaven. But the researches of our ingenious countrymen in exploring that sacred language of India, have dispelled some illusions, and greatly abated the admiration of the public for such eastern learning. From what we have been able to gather, the *Lilawati* is a very short and meagre performance, loaded with a silly preamble and colloquy of the Gods. It begins with the numeration by nine digits, and the supplementary cipher or small o, in what are called the *Devanagari* characters; and it contains the common rules of arithmetic, and even the extraction of the square root, as far as two places of figures; but the examples are generally very easy, scarcely forming any part of the text, and only written on the margin with red ink. Of fractions, whether decimal or vulgar, it treats not at all.

The Hindus pretend, that this arithmetical treatise was composed about the year 1185 of the Christian era. The date of a manuscript, however, is always very uncertain. We know besides, that the oriental transcriber is accustomed to incorporate without scruple such additions in the text as he thinks fit. Nor will any of the criteria which might ascertain the age of a manuscript apply to the eastern writings, where the composition of the paper, the colour of the ink, and the form of the characters, have for ages continued unchanged.

If the exuberant fancy of the Greeks led them far beyond the denary notation, it seems probable, that the feebler genius of the Hindus might just reach that desirable point, without diverging into an excursive flight. Though now familiar with that system, they are still unacquainted with the use of its descending decimal scale; and their management of fractions, accordingly, is said by intelligent judges to be tedious and embarrassed. In Plate XXVII. on the left hand, and near the bottom, we have given the Sanscrit digits, and have placed over them the numeral elements from which they might be formed. These consist of a succession of simple strokes, variously combined as far as nine. The resemblance to the *Devanagari* characters appears very striking. From these again, the common Hindu, and the vulgar Bengalee digits, are evidently moulded, with only slight alterations of figure. The Birman numerals, which we have copied from Symes' *Embassy to the Kingdom of Ava*, are manifestly of the same origin; only they have a thin, wirey body, being generally written on the palmyra-leaf with the point of a needle.

It appears, from a careful inspection of the manuscripts preserved in the different public libraries of Europe, that the Arabians were not acquainted with the denary numerals, before the middle of the thirteenth century of the Christian æra. They cultivated the mathematical sciences with ardour, but seldom aspired at original efforts, and generally contented themselves with copying their Grecian masters. The alphabet of the Arabians had been employed for expressing numbers exactly in the same way as that of the Greeks. The letters, in their succession, were sometimes applied to signify the lower of the ordinal numbers; but more generally they were distinguished into three classes, each composed of nine characters, corresponding to units, tens, and hundreds. Though, like most of the Oriental nations, the Arabians write from right to left, yet they followed implicitly the Greek mode of ranging the numerals, and performing their calculations. With the same deference, they received the other lessons of their great masters, and very seldom hazarded any improvement, unless where industry and patient observation led them incidentally to extend mensuration, and to rectify and enlarge the basis of Astronomy.

It seems highly probable, therefore, that the Arabians did not adopt the Indian numerals until a late period, and after the torrent of victory had opened an easy communication with Hindostan. They might derive their information through the medium of the Persians, who spoke a dialect of their language, had embraced the same religion, and were, like them, inflamed by the love of science and the spirit of conquest. The Arabic numerals, accordingly, resemble exceedingly the Persic, which are now current over India, and there esteemed the fashionable characters. But the Persians themselves, though no longer the sovereigns of Hindostan, yet display their superiority over the feeble Gentoos, since they generally fill the offices of the revenue, and have the reputation of being the most expert calculators in the East. It should be observed, however, that, according to Gladwin, these accountants have introduced a peculiar contracted mode of registering very large sums, partly by the numeral characters, and partly by means of symbols formed of abbreviated words. Yet Sir John Chardin relates, that the Persians have no proper terms to express numbers beyond a thousand, which they merely repeat, as our young arithmeticians often do, to signify a million or a billion.

The Indian origin of the denary numerals is farther confirmed by the testimony of Maximus Planudes, a monk of Constantinople, who wrote, about the middle of the fourteenth century, a book on practical arithmetic, entitled Λογιςικὴ Ινδικὴ, or Ψηφοφοϱιά κατ Ινδȣς̀, ἡ λεγομενη μεγάλη, that is, "the "great Indian mode of Calculating." In his introduction, he explains concisely the use of the characters in notation. But Planudes appears neither to have received his information directly from India, nor through the medium of the Persians, the nearest neighbours on the eastern confines of the Greek Empire. It is most probable that he was made acquainted with those numerals by his intercourse with

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Europe, having twice visited, on a sort of embassy, the Republic of Venice; for, of two manuscripts preserved in the library of St Mark, the one has the characters of the Arabians, and the other has that variety which was first current in Europe, while neither of them shows the original characters used in Hindostan.

Their introduction into Europe.

2. But the most important inquiry is, to ascertain the period at which the knowledge of our present numerals was first spread over Europe. As it certainly had preceded the invention of the art of printing, the difficulty of resolving the question is much increased by the necessity of searching and examining old and often doubtful manuscripts. Some authors would date the introduction of those ciphers as early as the beginning of the eleventh century, while others, with far greater appearance of reason, are disposed to place it two hundred and fifty years later.

While the thickest darkness brooded over the Christian world, the Arabians, reposing after their brilliant conquests, cultivated with assiduity the learning and science of Greece. If they contributed little from their own store of genius, they yet preserved and fanned the holy fire. Nor did they affect any concealment, but would freely communicate to their pupils and visitors that precious knowledge which they had so zealously drawn from different quarters. Some of the more aspiring youth, in England and France, disgusted with the wretched trifling of the schools, resorted for information to Spain; and having the courage to subdue the rooted abhorrence entertained in that age against Infidels, took lessons in Philosophy from the accomplished Moors. Among those pilgrims of science, the most celebrated was Gerbert, a monk, born of obscure parents, at Aurillac, in Auvergne, but promoted by his talents successively to the Bishopricks of Rheims and of Ravenna, and finally raised to the Papal chair, which he filled during the last four years of the tenth century, under the name of Sylvester II. This ardent genius studied Arithmetic, Geometry, and Astronomy, among the Saracens; and on his return to France, charged with various knowledge, he was esteemed a prodigy of learning by his contemporaries. Nor did the malice of rivals fail to represent him as a magician, leagued with the infernal powers. Gerbert wrote largely on Arithmetic and Geometry, and gave rules for shortening the operations of the *Abacus*, which he likewise termed *Algorismus*. In some manuscripts, the numbers are expressed in ciphers; but we are not thence entitled to infer, as many writers have done, that he had actually the merit of introducing those characters into Europe. The context of his discourse will not support such a conclusion. The figures were not, we have seen, still known to the Arabians themselves; and must have long afterwards been inserted in those copies, for the convenience of transcribers.

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Nor can we safely refer the introduction of Arabic figures to our famous Roger Bacon, whose various attainments and unwearied research after genuine knowledge, raised him far above the level of his contemporaries, but who, to the disgrace of his age and country, suffered a sharp persecution, and a tedious imprisonment, on the ridiculous charge of practising the redoubted arts of magic. But the writings of Bacon really discover no proofs of his acquaintance with the denary notation; and the fact commonly stated as an irresistible evidence in his favour, bears a very different interpretation. An almanack, now preserved in the Bodleian Library at Oxford, and containing numerals in their earliest forms, has, by the credulity of after-times, been, with all other feats and inventions, ascribed, of course, to the great necromancer. But unluckily this production is marked with the date 1292, the very year on which Bacon, after a lingering illness, expired; and it besides professes to have been calculated for the meridian of Tolouse, and had consequently been imported, without doubt, from France. *

About the same period, John of Halifax, named, in the quaint Latinity then used, *Sacro-Bosco*, who had likewise travelled, wrote his Treatise *De Sphæra*, in some copies of which the numbers are given in ciphers. But it appears from examination, that such abbreviations were introduced by the license of transcribers.

There is little doubt that the Arabic figures were first used by Astronomers, and afterwards circulated in the almanacks over Europe. The learned Gerard Vossius places this epoch about the year 1250; but the judicious and most laborious Du Cange thinks that ciphers were unknown before the fourteenth century; and Father Mabillon, whose diplomatic researches are immense, assures us, that he very rarely found them in the dates of any writings prior to the year 1400. Kircher, with some air of probability, seeks to refer the introduction of our numerals to the astronomical tables which, after vast labour and expence, were published by the famous Alphonso, King of Castile, in 1252, and again, more correctly, four years afterwards. But it is suspected that, in the original work, the numbers were expressed in Roman or Saxon characters. Two letters from that enlightened, but ill-requited prince, to our Edward I., which are preserved in the Tower of London, have the dates 1272 and 1278, still denoted by those ancient characters.

* Nothing appears to be worse founded than the attempts to represent the elder Bacon in the light of an original inventor. Notwithstanding the obscurity of his writings, it needs but a little criticism to dispel the conceits fomented by national partiality. Friar Bacon advances no claim even to the discovery of gunpowder, which has been so gratuitously ascribed to him. On the contrary, he admits that the boys in his time were acquainted with the use of this substance in fire-works; and he merely pretends, in a sort of anagram, to give a receipt for making it stronger and better than ordinary.

After the chief ingredient in the composition of gunpowder, under the mistaken names of *natron* or *nitrum*, and *saltpetre* or *rock-salt*, had been imported from the East, probably through the intervention of the Crusaders, its disposition to explode in the contact of inflammable matters, if not communicated along with it, could not remain for any time a secret. The explosive force was a very different, and a far more important property, which is perhaps rightly attributed to Schwartz, a German monk, who, in the course of his experiments, stumbled on it about the middle of the fourteenth century.

In the tenth volume of the *Archæologia*, the Rev. Mr North has given a short account of an almanack preserved in the library of Bene't College, Cambridge, and containing a table of eclipses for the cycle between 1330 to 1348. There is prefixed to it a very brief explication of the use of numerals, and the principles of the denary notation; from which we may see how imperfectly the practice of those ciphers was then understood. The figures are of the oldest form, but differ not materially from the present, except that the four has a looped shape, and the five and seven are turned about to the left and to the right. The one, two, three, and four, are likewise, perhaps for elucidation, represented by so many dots, thus, . .. ∴ ∷; while five, six, seven, and eight, are signified by a semicircle or inverted ɔ with the addition of corresponding dots—ɔ ɔ· ɔ: ɔ∴ Nine is denoted by o; ten by the same character, with a dash drawn across it; and twenty, thirty, or forty, by this last symbol repeated.

As a farther evidence of the inaccurate conceptions which prevailed respecting the use of the digits in the fourteenth century, we may refer to the mixture of Saxon and Arabic numerals which was copied from some French manuscripts by Mabillon, as exhibited in Plate XXVII. The Saxon 𝔵, signifying ten, is repeatedly combined with the ordinary figures; and 𝔵𝔵𝔵, 𝔵𝔵𝔵𝔦, are immediately followed by 302, and 303, which must have been therefore intended to signify *thirty-two* and *thirty-three*, the force of the cipher not being still rightly understood. It should be observed, that the Greek *episēmon* or *Fau*, for the number *six*, had come to be represented by a character similar to G. The Saxon dates are taken from the Danish and Norwegian registers, preserved in Suhm's *Northern Collections*.

One of the oldest authentic dates in the numeral characters is that of the year 1375, which appears written by the hand of the famous Petrarch on a copy of St Augustine, that had belonged to that distinguished Poet and Philosopher. The use of those characters had now begun to spread in Europe, but was still confined to men of learning. We have seen a short tract in the German language, entitled, *De Algorismo*, and bearing the date 1390, which explained, with great brevity, the digital notation and the elementary rules of arithmetic. What is very remarkable, the characters, in their earliest form, are ranged thus, 0, 9, 8, 7, 6, 5, 4, 3, 2, 1, from right to left, the order which the Arabians would naturally follow. But it was not very easy to comprehend at first the precise force of the *cipher*, which, insignificant by itself, only serves to determine the rank and value of the other digits. The name, derived from an Arabic word signifying *vacuity*, is sufficiently expressive; yet a sort of mystery, which has imprinted its trace on language, seemed to hang over the practice, for we still speak of *deciphering*, and of *writing in cipher*, in allusion to some dark or concealed art. After the digits had come to supply the place of the Roman numerals, a very considerable time probably elapsed before they were generally adopted in calculation. The modern practice of Arithmetic was unknown in England, till about the middle of the sixteenth century. But the lower orders, imitating the clerks of a former age, were still accustomed to reckon with their *counters* or *awgrym stones*. In Shakespear's comedy of the *Winter's Tale*, written at the commencement of the seventeenth century, the clown, staggered with a very simple multiplication, exclaims that he will try it with counters.

Arithmetic was long considered in England as a higher branch of science, and therefore left, like Geometry, to be studied at the University. Most of the public or grammar schools of the South were, on the suppression of the monasteries, erected a little after the Reformation, during the short but auspicious reign of Edward VI. They were accordingly destined by their founders merely for teaching the dead languages; and the too exclusive pursuit of the same system is now one of the greatest defects in the English plan of liberal education.

It cannot be doubted that the kalendars composed in France or Germany, and sent to the different religious houses, were the means of dispersing the knowledge of Arabic numerals over Europe. The library of the University of Edinburgh has a very curious almanack, presented to it, with a number of other valuable tracts, by the celebrated Drummond of Hawthornden, beautifully written on vellum, with most of the figures in vermillion. It is calculated especially for the year 1482, but contains the succession of lunar phases for three cycles, 1475, 1494, and 1513, with the visible eclipses of the sun and moon, from 1482 to 1530 inclusive. The date of this precious manuscript, which had once belonged to St Mary's Abbey at Cupar in Angus, is easily determined, and we have copied from it the oldest numerals exhibited in Plate XXVII. To these we have subjoined *fac similes* from Caxton's *Mirrour of the World*, and a wooden Cut from Shirwood's *Ludus Arithmomachiæ*, given in Dibdin's *Bibliotheca Spenceriana*.

The College accounts in the English Universities were generally kept in the Roman numerals, till the early part of the sixteenth century; nor in the parish registers were the Arabic characters adopted before the year 1600. The oldest date which we have met with in Scotland is that of 1490, which occurs in the rent-roll of the Diocese of St Andrew's, the change from Roman to Arabic numerals occurring, with a corresponding alteration in the form of the writing, near the end of the volume. The old characters in Plate XXVII. are copied from a manuscript history of the Scottish Bishopricks, apparently written about the year 1550, and now in the possession of Thomas Thomson, Esq. Advocate.*

* For want of attending to these facts, some learned Antiquaries have often suffered themselves to be grossly misled. Thus, Mr De Cardonnel, a respectable author, who has given views and short descriptions of the ancient edifices in Scotland, mentions, without marking the smallest doubt or surprise, that the date 1155 appears over the gateway of the ruins of the Castle of St Andrew's. But this front was built subsequent to the murder of the detested Cardinal Beaton, by Archbishop Hamilton, who likewise there affixed his Arms, but who long afterwards, on the capture of Dumbarton Castle, suffered an ignominious death, for his adherence to Queen Mary and the Popish faction. The real date was unquestionably 1555, only the second figure has been almost effaced by time and accident.

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Illustrations of the Rules of Figurate Arithmetic.

Having endeavoured to trace the origin and introduction of our numeral characters, it only remains now to explain the *operations of Figurate Arithmetic*. But, on this branch of the subject, we need not dilate; since the common rules, with their various modifications, are given at some length in the *Encyclopædia*. It will be more instructive to derive the practice of numbers from the principles already unfolded, in treating of *Palpable Arithmetic*. The same theory may likewise suggest other methods of varying and abridging the common operations. We shall follow the order observed under the first head, selecting as few examples as may be wanted for illustration. The *Denary* Scale, being the one generally received, will claim our chief attention; but we shall likewise compare its results with those of some other scales, particularly the *Duodenary*, which is partially adopted in commerce, and possesses certain peculiar advantages.

It would, in many cases, facilitate calculation, to have figures corresponding to the open counters. We have, therefore, to transform the ordinary characters into deficient digits, modifying their shape as much as to distinguish without entirely altering or disguising them. By help of such new figures, it will be easy to represent numbers by their defects as well as their excesses. This answers most conveniently in expressing the digits from 5 to 10. Thus 38 may be denoted by $4\bar{2}$, meaning 40 with 2 abated; for the same reason, 829 may be written $1\bar{2}3\bar{1}$, signifying that 1000 is to be diminished by 201.

For the operations with the *Duodenary Scale*, it becomes necessary to devise two additional characters for expressing *ten* and *eleven*. Not to seek far after such objects, we have contented ourselves with condensing the ordinary forms into ϕ and ϕ̸, which are perhaps sufficiently distinct, while they shadow out the figures represented by them.* We now proceed to explain the common operations.

### Addition.

Addition.

From the principle of numerical notation, it follows that addition is performed by collecting the digits of each bar or rank. Each class, whether it be units, hundreds or thousands, is treated in the same way. In adding two figures, it is only requisite to count forwards from one of them, as many steps as are signified by the other. Suppose 5 were to be joined to 8; reckoning onwards, we pass through 9, 10, 11, 12, to 13. This simple process may be more conveniently performed by counting over the fingers. But, for a learner, it is a preferable mode to frame a table of addition, which he may readily commit to memory. The construction and use of such a table are so very simple, as hardly to require any explanation. The one number occupies the horizontal row at the top, and the other the vertical row at the side. Thus, below the column of 7, and opposite to the horizontal range of 6, stands 13, the sum of these numbers. Such tables are found in the more ancient treatises of arithmetic; but they have been most injudiciously, as we think, omitted in the later systems of education.

ADDITION TABLE.

*Denary Scale.*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 |
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 2 |
| | | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 3 |
| | | | 8 | 9 | 10 | 11 | 12 | 13 | 4 |
| | | | | 10 | 11 | 12 | 13 | 14 | 5 |
| | | | | | 12 | 13 | 14 | 15 | 6 |
| | | | | | | 14 | 15 | 16 | 7 |
| | | | | | | | 16 | 17 | 8 |
| | | | | | | | | 18 | 9 |

Let it be sought to add these four numbers, 3709, 8540, 2618, and 706. Having set them in their ranks, the most natural way would be to write down the sum of each column. The first column on the right hand gives 23, the next 5, the third 25, and the last column 13. The same numbers, collected by a second summation, give for the final result 15573.

```
 3709
 8540
 2618
  706
 ----
   23
  255
 13
-----
15573
```

But the process would be rather shortened, by writing under each column the units of the sum, and below it the tens in a smaller character, which are to be joined to the figures of the next column in adding them. By a little practice, however, this precaution is rendered unnecessary, and the small subscribed figures are retained mentally, and *carried* to the successive higher columns.

```
 3709
 8540
 2618
  706
-----
15573
 1202
```

This operation is somewhat easier with deficient figures. Thus, the numbers may be changed into others with the defects interspersed. In this mode, there being a sort of counterbalance, it will seldom be required to carry any to the higher columns.

$$\begin{array}{r} 4\bar{3}1\bar{1} \\ 1\bar{2}540 \\ 3\bar{4}2\bar{2} \\ 1\bar{3}1\bar{4} \\ \hline 1658\bar{7} \\ \text{or } 15573 \end{array}$$

Suppose those numbers were all transferred to the *Duodenary Scale*; they will stand thus: The figures of the first column give by summation *twenty-one*; that is 19 by the *Duodenary Scale*. The others in succession yield the several sums annexed.

```
2 1 9 1
4 ϕ̸ 3 8
1 6 2 2
  4 ϕ ϕ
-------
    1 9
  2 0
1 ϕ
7
-------
9 0 1 9
```

If the condensed process be followed, the form will be a little different, and more distinct.

```
2 1 9 1
4 ϕ̸ 3 8
1 6 2 2
  4 ϕ ϕ
-------
9 0 1 9
  2 2 1
```

The operation will be somewhat shortened by introducing deficient figures; nor will there be any occasion for any carrying, the accumulated excess of the digits being partly counterbalanced by the intermixed defects.

$$\begin{array}{r} 2\,2\,\bar{3}\,1 \\ 5\,\bar{1}\,4\,\bar{4} \\ 2\,6\,2\,2 \\ 5\,\bar{1}\,\bar{2} \\ \hline 9\,0\,2\,3 \\ \text{or } 9\,0\,1\,9 \end{array}$$

To facilitate the working on the *Duodenary Scale*, it would be expedient to construct an Addition Table. By means of this, we may at once sum up a row of pence, and carry the excess to the place of shillings.

* *These characters are larger, and differently shaped from what was intended; but is too late now to correct the oversight of the artist.*

Figurate Aritametic.

### Addition Table.

*Duodenary Scale.*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | ↊ | ↋ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | ↊ | ↋ | 10 | 1 |
| | 4 | 5 | 6 | 7 | 8 | 9 | ↊ | ↋ | 10 | 11 | 2 |
| | | 6 | 7 | 8 | 9 | ↊ | ↋ | 10 | 11 | 12 | 3 |
| | | | 8 | 9 | ↊ | ↋ | 10 | 11 | 12 | 13 | 4 |
| | | | | ↊ | ↋ | 10 | 11 | 12 | 13 | 14 | 5 |
| | | | | | 10 | 11 | 12 | 13 | 14 | 15 | 6 |
| | | | | | | 12 | 13 | 14 | 15 | 16 | 7 |
| | | | | | | | 14 | 15 | 16 | 17 | 8 |
| | | | | | | | | 16 | 17 | 18 | 9 |
| | | | | | | | | | 18 | 19 | ↊ |
| | | | | | | | | | | 1↊ | ↋ |

It is evident, that the mode of operation will still be the same in the descending terms of any scale. The only thing needed is to preserve the respective ranks of the figures; to secure which, a point may be placed between the units and the fraction. Let the annexed example of integers and decimals be proposed. The fractional part of the sum thus corresponds to *one-fourth*.

| |
|---|
| 602.765625 |
| 370.40625 |
| 81.078125 |
| 1054.250000 |

Suppose deficient figures were employed. The several numbers might assume this form: As generally happens in such cases, no carrying whatever is here wanted.

| |
|---|
| $1\bar{4}03.\bar{2}\bar{4}6\bar{4}25$ |
| $4\bar{3}0.40\bar{4}25$ |
| $1\bar{2}1.1\bar{2}\bar{2}125$ |
| 1154.350000 |
| or 1054.25 |

The same numbers reduced to the *Quaternary Scale* will stand thus: Their addition is extremely simple, and gives of course the same result.

| |
|---|
| 21122.301 |
| 11302.122 |
| 1101.011 |
| 100132.100 |

Subtraction.

Subtraction. This operation having for its object to find the difference between two numbers, is precisely the reverse of addition. The same auxiliary table may hence answer for both. Thus, if 7 joined to 6 makes 13, it is equally clear, that 7 taken away from 13 must leave 6. For the sake of distinction, the greater of the two numbers is called the *Minuend* and the other one the *Subtrahend*.

The method of proceeding will be most clearly perceived from the inspection of an example. Let it be required to take 428053 from 702632. Here, beginning at the right hand, 3 cannot be taken from 2, but the effect will evidently be the same if ten were added to both the minuend and the subtrahend. Ten may therefore be joined to the 2, while one, as equivalent to it, is thrown to 5, which occupies the place higher. This addition of the 10 is called *borrowing*, and the countervailing addition of 1 in the next bar is called *carrying*. Take 3 then from 2, with the junction of 10 borrowed, or 12, and there remains 9. Now 5, with the addition of the unit carried, or 6, is to be taken from 3: To do this, 10 is again borrowed, making the figure of the minuend 13, which leaves 7; and the 1 carried to 0 in the higher place, is taken from 6, and therefore leaves 5. Again, 8 taken from 2 with the addition of 10, leaves 4; and the same addition of 10 is made to the subtrahend, by joining 1 to the 2 which stands a place higher. But 3 taken from 0 increased to 10, gives 7, for the remainder; and 1 carried to the 4, and subtracted from 7, leaves 2, as the last difference.

| |
|---|
| 702632 |
| 428053 |
| 274579 |

Figurate Arithmetic.

Let the same example be worked with deficient digits. In subtracting the lower number, it is only required to change the character of its digits, and then add them. The operation, therefore, needs no farther explanation.

| |
|---|
| $703\bar{4}32$ |
| $43\bar{2}153$ |
| $3\bar{3}558\bar{1}$ |
| or 274579 |

Next, suppose those numbers were converted into the *Duodenary Scale*. The subtraction will be performed thus: It is only to be observed, that when there is occasion for borrowing, *twelve* is joined to the digit of the minuend, and *one* is carried or annexed to the higher digit of the subtrahend.

| |
|---|
| 2 9 ↊ 7 4 8 |
| 1 8 7 8 7 1 |
| 1 1 2 ↊ 9 7 |

Since the terms of a descending scale are treated in the same way, it would, perhaps, be superfluous to take examples of the subtraction of decimal fractions.

### Multiplication.

Multiplication.

This operation, it was observed, is nothing but a repeated addition. The object which it seeks, is to add, for a *Product*, the *Multiplicand*, as often as there are units contained in the *Multiplier*. But such a process would have proved intolerably tedious, if the principle of numerical arrangement had not come to lend its aid. As in the *Denary Scale*, for instance, any digit is augmented tenfold at each shift to a higher place; so its product into the Multiplicand will give a similar increase, in the ascending progression, and must consequently maintain a corresponding value. Suppose it had been required to multiply 57 by 23; the most obvious way of proceeding would be this. First, the 57 is added *three* times, making 171. Next, the same number advanced a place higher, or having a zero annexed to it, is added *twice*, corresponding to the *two* of the multiplier, which, from its situation, has the value of 20. To this sum, or 1140, is joined the other, making in all 1311, for the compound product.

| | |
|---|---|
| 570 | 57 |
| 570 | 57 |
| | 57 |
| 1140 | |
| 171 | 171 |
| 1311 | |

But the operation is shortened by performing mentally this repetition or summation, of each digit in the multiplicand. Thus, resuming the last example: 7 repeated *three* times makes 21, and 5 repeated as often on the advanced bar gives 15; again, 7 repeated *twice*, and moved a place higher, makes 14, and 5 likewise repeated *twice*, and shifted a place still higher, gives 10. The general amount is 1311, the same as before.

| |
|---|
| 57 |
| 23 |
| 21 |
| 15 |
| 14 |
| 10 |
| 1311 |

Such, we have seen, was the method practised by the Greeks; but in many cases this procedure becomes excessively tedious and perplexed. It is much simpler, by *carrying*, as in the process of Addition, to consolidate the figures at once on each bar, before they are written down. Instead of noting the 2 of the first product 21, it is joined immediately to the next product 15, and the sum 17 written down. Again, in the next row, the higher figure of the product 14 is combined at once with the lower figure of the next product 10, making 114.

| |
|---|
| 57 |
| 23 |
| 171 |
| 114 |
| 1311 |

Figurate Arithmetic.

This now is the ordinary form of Compound Multiplication, and it seems scarcely to admit of any material improvement. But, to shorten the repeated summation of digits, it is expedient to construct a table, which must be engraved in the memory of the arithmetician. The mechanical method of multiplying digits, which has been already explained, may serve as an useful auxiliary, in fixing the recollection of the series of products. The table itself, though ascribed to Pythagoras, is most easily framed; but, notwithstanding, it has become now so very common, we make no hesitation in copying it, especially as we design to introduce another accommodated to the *Duodenary Scale.*

MULTIPLICATION TABLE.

*Denary Scale.*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 1 |
| | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 2 |
| | | 9 | 12 | 15 | 18 | 21 | 24 | 27 | 3 |
| | | | 16 | 20 | 24 | 28 | 32 | 36 | 4 |
| | | | | 25 | 30 | 35 | 40 | 45 | 5 |
| | | | | | 36 | 42 | 48 | 54 | 6 |
| | | | | | | 49 | 56 | 63 | 7 |
| | | | | | | | 64 | 72 | 8 |
| | | | | | | | | 81 | 9 |

It may be observed, that the numbers 1, 4, 9, 16, 25, 36, 49, 64, and 81, which occupy the diagonal, are the second powers or squares of the successive digits. From the inspection of the table, we gather that *one* is the terminating figure in the *three* products 1, 21, and 81; that *two* terminates the *six* products 2, 12, 12, 32, 42, and 72; that *three* occurs as the terminating figure in only the *two* products 3 and 63; that *four* terminates the *four* products, 4, 14, 24, and 54; that *five* terminates likewise the *five* products 5, 15, 25, 35, and 45; that *six* is the terminating figure in the *five* products, 6, 16, 16, 36, and 56; that *seven* terminates only the *two* products 7 and 27; that *eight* terminates the *five* products, 8, 18, 28, and 48; and that *nine* occurs only *twice* as the terminating figure, in 9 and 9. It hence follows, that, out of *thirty-four* chances, there are *six* that any composite number should end in 2; *five* chances that it should end in 5, 6, or 8; *four* chances that it should end in 4; *three* chances that it should end in 1; *two* chances that it should end in 3 or 7; and *two* chances likewise that the terminating figure should be 9. These very different proportions in the recurrence of the several digits at the end of a number, may be remarked in the large tables of products. It likewise appears, that the bulk of the prime numbers must terminate with 9, 3, or 7, and the rest with 1.

It may be instructive, to compare the operation of an example of compound multiplication in the ordinary way, with another performed by deficient figures.

| | |
|---|---|
| 4819 | $5\bar{2}2\bar{1}$ |
| 378 | $4\bar{2}\bar{2}$ |
| 38552 | $\bar{1}04\bar{4}2$ |
| 33733 | $\bar{1}04\bar{4}2$ |
| 14457 | $2088\bar{4}$ |
| 1821582 | $2\bar{1}82\bar{4}\bar{2}2$ |
| | or $19816\bar{2}2$ |
| | and 1821582 |

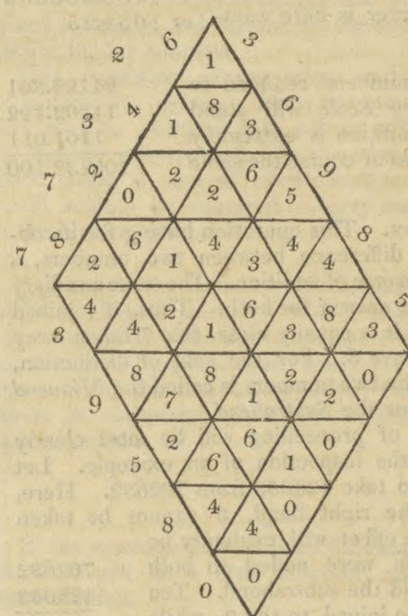
In this instance, the working is evidently easier with the deficient figures, since lower digits are concerned in the multiplication. But it must be observed, that a deficient figure changes the character of all the digits which it multiplies. The restoration of the ordinary figures is better understood from being made, as here, by successive steps.

The same example treated after the method of the Greeks, where each product of the digits is set down separately, without any previous consolidation by *carrying,* will appear far more complex. This process may be conducted either from right to left, or from left to right, since each step is entirely independent of the rest. We have preferred the former mode, because it approaches nearer to the one generally practised.

```
   4819
    378
   ----
     72
    648
    32
     63
    567
   28
     27
    243
   12
-------
1821582
```

Persian Mode of Multiplication.

The Persians, who probably communicated to the Arabians the knowledge of the Indian numeral characters, but who had likewise carefully studied the astronomy and arithmetic of the Greeks, made a capital step towards the improvement of the ancient mode of calculation. This will be readily understood from an example which we shall borrow from the judicious travels of Sir John Chardin. Suppose it were sought to multiply the number 36985 by 6428. The Persian Arithmeticians, having drawn a rhomboid, would, beginning at the top, write these numbers downwards along the upper sides, and then divide the figure into equilateral triangles, by combining oblique, with horizontal, lines.




```
    36985
     6428
    -----
   18
    36
     54
      48
       40
   12
    24
     36
      32
   6
    12
     18
      16
       10
   24
    48
     72
      64
       40
---------
237739580
```

Now, the multiplication is carried along the rows on the left side of the rhomboid: 6 into 3 gives 18, which is disposed in the uppermost triangle and the one below it; 6 into 6 gives 36, which is deposited in the two next triangles; and the same process is continued through the series. Again, 4 times 3 makes 12, which is placed in the two uppermost triangles of the next row. The rest of the operation of filling the triangles is easily understood. But to collect the products, the figures in each horizontal row, beginning at the bottom, are added up, and the tens carried to the one immediately above it. Thus, the zero at the point of the rhomboid remains unchanged; in the row above this, 4, 4, 0 make 8; in the next row, 2, 6, 6, 1, 0 make 15, and 5 being set

Figurate Arithmetic.

down, the 1 is carried to the higher row, 8, 7, 8, 1, 2, 2, 0, making 29, of which 9 is set down, and 2 carried to the row above it. In this way, the summation is quickly performed, giving 237739580 for the complete product.

To show the advantage of this contrivance, we have exhibited opposite to it the same multiplication after the Greek method. It is easy to perceive, that the straggling figures which there occupy the vertical columns, are precisely the same as those which the Persians, by means of their triangular cells, concentrate in horizontal rows. The oblique direction of the original multiplication might suggest the use of the rhomboid. The process of the Persians requires very little effort or skill; but, as Chardin justly remarks, a European, moderately acquainted with ciphers, would finish the calculation before the Oriental had traced his diagram.

It will be admitted, however, that such artificial helps may prove useful in laborious and protracted multiplications, by sparing the exercise of memory, and preventing the attention from being overstrained. Of this description are the *Rods* or *Bones*, which we owe to the early studies of the great Napier, whose life, devoted to the improvement of the science of calculation, was crowned by the invention of Logarithms, the noblest conquest ever achieved by man. The application of these rods resembles so much the Persian mode of operation, that we are tempted to revert to their construction. The multiplication table being formed into a complete square, and the interior cells parted by diagonal lines running obliquely downwards from right to left, the numbers of each vertical column thus divided are engraved on corresponding slips of ivory or bone, while another slip, called the *index rod*, is marked with the successive digits. Let us resume the former example: The rods, beginning with the several figures of the multiplicand, 36985, are selected and set in the same order, with the index placed before them; then, opposite to the several figures of the multiplier, 6428, on the index, but going backwards, the numbers in each horizontal column are taken, the pair of digits in each rhombus, or double triangle, being always added; and finally, these rows of the products corresponding to each digit of the multiplier, being transcribed and properly disposed, are collected into one sum.

| 1 | 3 | 6 | 9 | 8 | 5 |
|---|---|---|---|---|---|
| 2 | /6 | 1/2 | 1/8 | 1/6 | 1/0 |
| 3 | /9 | 1/8 | 2/7 | 2/4 | 1/5 |
| 4 | 1/2 | 2/4 | 3/6 | 3/2 | 2/0 |
| 5 | 1/5 | 3/0 | 4/5 | 4/0 | 2/5 |
| 6 | 1/8 | 3/6 | 5/4 | 4/8 | 3/0 |
| 7 | 2/1 | 4/2 | 6/3 | 5/6 | 3/5 |
| 8 | 2/4 | 4/8 | 7/2 | 6/4 | 4/0 |
| 9 | 2/7 | 5/4 | 8/1 | 7/2 | 4/5 |

Thus, opposite to 8, the last digit of the multiplier, and proceeding from the right along the horizontal column, there occur these figures: 0, 4, and 4, or 8; 6, and 2, or 8; 7, and 8, or 15; and 1 carried to 4 and 4 makes 9; and lastly, the 2. The other rows are easily formed in the same way. If the horizontal columns opposite to 8, 2, 4, and 6, were supposed to be detached and combined into an oblique group, the similarity to the Persian mode would be very striking.

```
   295880|8
    73970|2
  147940 |4
 221910  |6
---------
237739580
```

But, without formally adopting either the figurate rods or the rhomboidal cells, it will sometimes be convenient, in very long multiplications, to form, by successive additions, an extemporaneous tablet of the digital products of the multiplicand. The application of this help is easily conceived.

It is evident, from the nature of notation, that, in the descending scale, the products corresponding to each figure of the multiplier, instead of being advanced, should be shifted backwards. Hence the common rule for the multiplication of decimal fractions—to cut off as many decimals as are found in both factors. But, since the remote decimals are of trifling import, a very commodious abbreviation is, to begin the process at the place of units. Passing to the 6 of the multiplier, the last figure 6 of the multiplicand is struck off; but, as it would have given 36, the nearest whole number 4, expressing the tens, is carried to the product of 6 into 3, making 22. The same thing is repeated at each multiplication.

```
 4.236
 1.618
------
 4.236|
 2.542|
    42|
    34|
------
 687.4
```

We shall now compare the ordinary method of multiplying numbers with the same process performed by deficient figures. By a little practice, the working with deficient figures would evidently become easier, and more expeditious than the common way.

| | |
|---|---|
| | $4\bar{3}0\bar{2}5$ |
| 36985 | $1\bar{4}43\bar{2}$ |
| 6428 | 86030 |
| 295880 | 129055 |
| 73970 | $15\bar{2}060$ |
| 147940 | $\bar{1}52060$ |
| 221910 | $4\bar{3}0\bar{2}5$ |
| 237739580 | $3\bar{7}8\bar{2}66580$ |
| | or 237739580 |

In farther illustration of the process of multiplication, we shall perform the same examples on the *Duodenary Scale*. It will be convenient, however, though not quite essential, to construct previously a table of products.

MULTIPLICATION TABLE.

*Duodenary Scale.*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | ϕ | ϕ̸ | 1 |
| | 4 | 6 | 8 | ϕ | 10 | 12 | 14 | 16 | 18 | 1ϕ | 2 |
| | | 9 | 10 | 13 | 16 | 19 | 20 | 23 | 26 | 29 | 3 |
| | | | 14 | 18 | 20 | 24 | 28 | 30 | 34 | 38 | 4 |
| | | | | 21 | 26 | 2ϕ̸ | 34 | 39 | 42 | 47 | 5 |
| | | | | | 30 | 36 | 40 | 46 | 50 | 56 | 6 |
| | | | | | | 41 | 48 | 53 | 5ϕ | 65 | 7 |
| | | | | | | | 54 | 60 | 68 | 74 | 8 |
| | | | | | | | | 69 | 76 | 83 | 9 |
| | | | | | | | | | 84 | 92 | ϕ |
| | | | | | | | | | | ϕ01 | ϕ̸ |

Let it be required then to multiply the number 4819 by 378. Transformed into the *Duodenary Scale*, they will stand thus: The same operation is likewise here performed by deficient figures.

```
    2957        3365
     276         356
   -----     -------
    1896      154φ6
  17631     12141
  56φ̸2      9853
  -------   --------
  73φ1φ6    89φ1φ̸6
             73φ1φ6
```

Suppose the large numbers 36985 and 6428 were now converted into the *Duodenary Scale*, their multiplication, in common, and in deficient figures, would proceed in this manner.

```
     194φ1         23521
      3878          4484
   -------      --------
    123288        71884
   1059φ7       129348
  123288        71884
  54263        71884
  --------     ---------
  67750938     758713344
               67750938
```

But this scale is of greater consequence, when viewed in the descending progression, since the duodecimal subdivision has, to a certain extent, obtained currency in the denomination of money, and of weights and measures. A few examples will explain the management of these fractions. Suppose it were sought to multiply L. 6, 15s. 3¾d. by 53, the operation with Duodecimals will be performed thus:

```
     6.923       6.765625
    45.         53.
   --------    ----------
    29.9φ̸3     20.296875
   230.90      338.28125
   --------    ----------
   25φ.6φ̸3    358.578125
```

The product 25φ.6φ̸3 converted again into the *Denary Scale*, gives L. 358, 11s. 6½d. This result is more easily brought out than by Decimals, as appears by the comparison. If the Pound Sterling had been divided into 12 shillings, as the shilling is into 12 pence, the application of Duodecimals to accounts would have been extremely convenient.

Duodecimals are best adapted, however, to mensuration, where feet, inches, and their subordinate parts, enter into play. Thus, if it were required to find the solid contents of a log of timber, 2 feet 7¼ inches square, and 27 feet 5½ inches long. The successive multiplications would be performed in this way, all the figures below the fourth place being excluded, as of little significance. The result is 190 cubic feet, with about 2½ twelfth parts, most inaccurately called, in this case, cubic inches.

```
      2.73
      2.73
     ------
      5.26
      1.629
        799
     -------
      6.9469
     23.56
   ---------
    116.9160
     20.4183
      2.9φφφ̸
       .3483
   ---------
    13φ.2695
```

But these fractions will likewise readily apply to the mensuration of round timber; for the relation of the circle to its circumscribing square, would be expressed in duodecimals by the number .9512. Suppose, for example, a cylinder 4 feet 2¾ in diameter, and 41 feet 10½ long.

The operation is thus performed: Four places of duodecimals only are retained, though in actual practice two places may generally be reckoned more than sufficient. The area of the circular base hence exceeds by a minute fraction 14 square feet, but the solid contents of the cylinder amounts extremely nearly to 700⅔ cubic feet. A similar mode of proceeding could easily be extended to the mensuration of cones and spheres.

```
     4.29
     4.29
   -------
    14.φ̸0                12.0723
      .856                41.φ6
      .3209             ----------
   --------              482.4900
    15.φ769               12.0723
      .9512                φ̸.8600
   --------                 .6037
    11.4φ̸81             ----------
      .7552              4φ4.7φ5φ
        160
         30
   --------
    12.0723
```

## Division.

This process, being exactly the reverse of Multiplication, consists in *subtracting* one number repeatedly from another. The former is called the *Divisor*, and the latter the *Dividend*, while the answer, signifying how often the subtraction needs to be made, is termed the *Quotient*. The principle of numerical arrangement suggests the means of abridging this operation. Suppose it were sought to divide 1554 by 37: Let 37 be subtracted in succession from 155, which, standing one place higher than the units, corresponds to tens; the several subtractions are marked by I, II, III, and IV, which belong to the place of tens, and from remainder 7 with 4 annexed to it, the divisor 37 is again subtracted twice. Whence the quotient is 42, or the number of times that 37 is contained in 1554, or must be subtracted before it exhausts this dividend.

```
       1554         74
  I.    37     I.   37
       ---         ---
       118          37
  II.   37     II.  37
       ---         ---
        81           0
  III.  37
       ---
        44
  IV.   37
       ---
         7
```

But such an operation is evidently circuitous. The most obvious improvement is to frame, as in compound multiplication, a small tablet of the digital products of the divisor, and to subtract always the nearest less number from the successive terms of the dividend and the remainder. Let it be required to divide 22028148 by 423. The tablet of products is formed by the successive addition of the divisor 423 and its multiples; of these, the number opposite to 5 comes nearest to the first four terms of the dividend; and the remainder 87, with the next figure annexed to it, is approached the nearest by 846, the next remainder 32 with the annexed 1 is less than the divisor, and, therefore, a zero is put in the quotient to preserve the place, and the following figure 4 is joined. The rest of the operation is easily conceived.

```
  1|  423)22028148(52076
  2|  846  2115
  3| 1269   ----
  4| 1692    878
  5| 2115    846
  6| 2538    ----
  7| 2961    3214
  8| 3384    2961
  9| 3807    ----
              2538
              2538
              ----
                 0
```

This method, however, is more tedious than needful, unless the quotient should consist of several figures. In other cases, a little practice will show how to choose the proper multiples of the divisor. Deficient figures may likewise be sometimes introduced with advantage. An example will explain this: The

Figurate Arithmetic.

dots placed under the figures of the dividend as fast as they are taken down, or annexed for a new division, point out the ranks of the divisor. With the deficient figures, the operation is somewhat easier, though it was unnecessary to make any alteration on the dividend itself.

```
472)1797848(3809      532)18022592(4211
    1416···               1928···
     3818                 1102
     3776                 1064
       4248                1425
       4248                 532
          0                1532
                            532
                              0
```

In the course of working, it will often happen that the product of the divisor, after being written down, will appear greater instead of less than the part of the dividend from which this is to be taken, but without substituting a lower product, the oversight would be rectified by a deficient digit at the next step. Thus, instead of the first two figures 38 of the quotient, we obtain 42, which is equivalent.

Fractions.

But should there be any remainder, it is evident that, by annexing successive ciphers, the division might still be carried on along the descending scale. Hence the process for converting vulgar into decimal fractions. A few examples will elucidate this practice.

```
(1.) 64)15.000000(.234375       (2.) 625)23.0000(.0368
         128·····                         1875
          220                              4250
          192                              3750
           280                              5000
           256                              5000
            240                                0
            192
             480       (4.) 81)1.000000000(.012345679
             448                81·······
              320               190
              320               162
                0                280
                                 243
(3.) 13)7.000000(.538461          370
         65·····                  324
          50                       460
          39                       405
           110                      550
           104                      486
             60                      640
             52                      567
              80                      730
              78                      729
               20                      *1
               13
               *7
```

In the *first*, a remainder 15, expressed in tenths, hundredths, thousands, &c. is divided by 64, and the quotient .234375 therefore expresses decimally the value of the fraction $\frac{15}{64}$; in the *second* example, it is necessary to annex ciphers before the division begins, and the result .0368 consequently represents the fraction $\frac{23}{625}$.

In both these examples, the operation terminates; but it will oftener happen, in the progress of the division, that the same remainder again emerges, after which the figures in the quotient must evidently maintain a perpetual recurrence. Thus, in the *third* example, the remainders of the division are successively 5, 11, 6, 8, 2, and again 7; from which point the series will recommence. The fraction $\frac{7}{13}$ is therefore, when expanded into decimals, .538461,538461,538461,&c. continued in perpetual circulation. In the *fourth* example, the remainders are 19, 28, 37, 46, 55, 64, 73, and then 1 as at first; here consequently a recurrence takes place, and the value of the fraction $\frac{1}{81}$ is expressed in these circulating decimals .012345679, 012345679, 012345679, &c. In every case, the number of different remainders, and consequently the variety of changes, must obviously be less than the divisor. The last example is extremely remarkable, since it brings out all the digits in their natural succession, except 8. The reason of such a curious result, is that $\frac{1}{81}$, being the square of $\frac{1}{9}$, which, expanded into decimals, is .11111111, &c. will be expressed by this product: The value of the fraction $\frac{1}{81}$, is therefore expressed, by the successive figures 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, &c. continued for ever, through all the descending places of the *Denary Scale*; but, at the junction of every *ten*, the order of the digits is partially disturbed; for the 11 behind the 10 changes it into 11, and this changes the 9 into 10, which again, by its influence, converts the 8 into 9.*

```
 .1111111111, &c.
 .1111111111, &c.
 .01111111111
    111111111
     11111111
      1111111
       111111
        11111
         1111
          111
           11
            1
 .01234567901,&c.
```

Different Scales of Notation.

Nothing more clearly discloses the properties of numbers, than the transferring of them to different scales of arrangement. Reckoning them, for instance, by successive braces, leashes, warps, &c. they are disposed on the *Binary*, *Ternary*, *Quaternary*, and succeeding scales. This process, requiring only the continued division by *two*, *three*, *four*, &c. is readily performed with figures. To procure greater variety in the results, we shall take a number that is rather large.

Let it be sought to exhibit the number 2138507 on successive scales. Its decomposition will be thus effected:

* The formation of circulating decimals affords a fine illustration of that secret concatenation which binds the succession of physical events, and determines the various though lengthened Cycles of the returning seasons—a principle which the ancient Stoics, and some other Philosophers, have boldly extended to the moral world:

> Alter erit tum Tiphys, et altera quæ vehat Argo
> Delectos heroas: erunt etiam altera bella,
> Atque iterum ad Trojam magnus mittetur Achilles.——See *Monthly Review*, vol. xviii. p. 14—17.

BINARY.

2)2138507

| | |
|---|---|
| 1069253 | 1 |
| 534626 | 1 |
| 267313 | 0 |
| 133656 | 1 |
| 66828 | 0 |
| 33414 | 0 |
| 16707 | 0 |
| 8353 | 1 |
| 4176 | 1 |
| 2088 | 0 |
| 1044 | 0 |
| 522 | 0 |
| 261 | 0 |
| 130 | 1 |
| 65 | 0 |
| 32 | 1 |
| 16 | 0 |
| 8 | 0 |
| 4 | 0 |
| 2 | 0 |
| | 0 |

TERNARY.

3)2138507

| | |
|---|---|
| 712835 | 2 |
| 237611 | 2 |
| 79203 | 2 |
| 26401 | 0 |
| 8800 | 1 |
| 2933 | 1 |
| 977 | 2 |
| 325 | 2 |
| 108 | 1 |
| 36 | 0 |
| 12 | 0 |
| 4 | 0 |
| 1 | 1 |

QUATERNARY.

4)2138507

| | |
|---|---|
| 534626 | 3 |
| 133656 | 2 |
| 33414 | 0 |
| 8353 | 2 |
| 2088 | 1 |
| 522 | 0 |
| 130 | 2 |
| 32 | 2 |
| 8 | 0 |
| 2 | 0 |

QUINARY.

5)2138507

| | |
|---|---|
| | 2 |
| 427701 | 1 |
| 85540 | 0 |
| 17108 | 3 |
| 3421 | 1 |
| 684 | 4 |
| 136 | 1 |
| 27 | 2 |
| 5 | 0 |
| 1 | |

SENARY.

6)2138507

| | |
|---|---|
| 356417 | 5 |
| 59402 | 5 |
| 9900 | 2 |
| 1650 | 0 |
| 275 | 0 |
| 45 | 5 |
| 7 | 3 |
| 1 | 1 |

SEPTENARY.

7)2138507

| | |
|---|---|
| 305501 | 0 |
| 43643 | 0 |
| 6234 | 5 |
| 890 | 4 |
| 127 | 1 |
| 18 | 1 |
| 2 | 4 |

OCTARY.

8)2138507

| | |
|---|---|
| 267313 | 3 |
| 33414 | 1 |
| 4176 | 6 |
| 522 | 0 |
| 65 | 2 |
| 8 | 1 |
| 1 | 0 |

NONARY.

9)2138507

| | |
|---|---|
| 237611 | 8 |
| 26401 | 2 |
| 2933 | 4 |
| 325 | 8 |
| 36 | 1 |
| 4 | 0 |

UNDENARY.

11)2138507

| | |
|---|---|
| 194409 | 8 |
| 17673 | 6 |
| 1606 | 7 |
| 146 | 0 |
| 13 | 3 |
| 1 | 2 |

DUODENARY.

12)2138507

| | |
|---|---|
| 178208 | φ |
| 14850 | 8 |
| 1237 | 6 |
| 103 | 1 |
| 8 | 7 |

Hence the same number 2138507 will be thus represented on the different scales:

| | |
|---|---|
| Binary | 1000001010000110001011 |
| Ternary | 11000122110222 |
| Quaternary | 20022012023 |
| Quinary | 1021413012 |
| Senary | 113500255 |
| Septenary | 24114500 |
| Octary | 10120613 |
| Nonary | 4018428 |
| Denary | 2138507 |
| Undenary | 1230768 |
| Duodenary | 87168φ |

The notation may be readily transferred to any higher scale which has, for its index, some power of that of the lower. If the number be distinguished into periods, consisting of two, three, or four places, the amount of these may be condensed into a single figure; and the corresponding index is the second, third, or fourth power of the primary index. Thus, let the expression 10,00,00,10,10,00,01,10,00,10,11 of the *Binary Scale* articulate at every alternate place from the right hand; the value of each period being substituted, or 1 for 01, 2 for 10, and 3 for 11, will transform the whole into this Quaternary arrangement 20022012023. If the same expression be divided into triplets 1,000,001,010,000,110,001,011, and each of these afterwards compressed into a single figure, assuming 1 for 001, 2 for 010, and 4 for 100, it will be changed into the Octary notation 10120613. In like manner, if the representation of the same number on the *Ternary Scale*, 11,00,01,22,11,02,22 be broken at every alternate place, and the values of those periods adopted, 1 being substituted for 01, and 3 for 10, the whole will be converted into the expression of the Nonary Scale, 4018428.

From the principle before investigated, we shall easily find the remainder of the division of the original number, by another number, which is one less than the index of any particular scale. Thus, to begin with the *Ternary Scale*, if the amount of all the figures be divided by two; or, what is the same thing, if every *two* be rejected and the other figures be successively added, retaining only at each step the excess above *two;* and at the end of the operation there will be left *one*. Hence it might be concluded that 2138507 is an odd number; a property indicated also by the character of its last digit. In the *Quaternary Scale*, by adding the figures together, and constantly throwing out the *threes*, there remains *two;* which shows that the division of the original number by *three* would leave *two*. In the *Quinary Scale*, the several figures being collected, omitting the *fours* as they arise, give *three* for the remainder of a division of 2138507 by *four;* which is indeed apparent from the inspection of its two last digits. In the *Senary Scale*, omitting all the *fives*, there is left only *two;* a remainder which might indeed be inferred, from the circumstance that the last digit of the original number was *seven*. In the *Septenary Scale*, collecting the figures, and rejecting the *sixes*, there is an excess of *five;* the same which is left by the division of the original number by *six*. In the *Octary Scale*, when the *sevens* are thrown out, *nothing* remains; which shows that the number was divisible by *seven*. In the *Nonary Scale*, rejecting the *eights*, there is left *three;* but this remainder of the division of the original number by *eight*, might be inferred from the simple inspection of the three last digits 507, since all the rest, being thousands, are evidently divisible by *eight*. In the *Denary Scale*, by adding the figures, and separating the *nines* as fast as they arise, there is still a surplus of *eight;* being the remainder of the division of 2138507 by *nine*. It thus appears, that the common operation of *casting out the nines* is only the application of a general principle to the received system of notation. But to pursue the illustrations,—in the *Undenary Scale*, by casting out the *tens*, there is left *seven* or the digit of the original number, or the remainder of its division by *ten*. Finally, in the *Duodenary Scale*, by rejecting the *elevens* from the collected figures, there remains *eight*, the last figure in the preceding scale, or the residue of the division of the original number by *eleven*. In general, we may perceive the terminating figure of the expression on any scale is the same, as the remainder of the division, by its index, on the next higher scale.

But the quotients of those divisions are, likewise, directly discovered from what was unfolded under Palpable Arithmetic. Not to multiply examples, let us begin with the *Senary Scale*. If the figures

be repeated on all the lower places, their summation will appear thus: The excesses corresponding to the several rows, amount to 22, which leaves 2, and gives 4 to the next column. The sum of this again, with the 4 borrowed, is 21, which contains 6 *three* times, with a remainder of 3. The 3 is then carried to the next column, and the operation repeated; the result is 13100033, which, being transferred from the *Senary* to the *Denary Scale*, gives 427701 for the quotient of the number 2138507 by 5.

| | |
|---|---|
| 1111111 | 1 |
| 111111 | 1 |
| 333333 | 3 |
| 55555 | 5 |
| 22 | 2 |
| 5 | 5 |
| | 5 |
| 1310002 3 | 2 |

The expressions on some of the other scales may be treated more concisely.

OCTARY SCALE.

| | |
|---|---|
| 111111 | 1 |
| 11111 | 1 |
| 2222 | 2 |
| 66 | 6 |
| 1 | 1 |
| | 3 |
| | 0 |
| 1124535 | |

Which, transferred to the *Denary Scale*, gives 305501 for the quotient of the original number by *seven*.

NONARY SCALE.

| | |
|---|---|
| 444444 | 4 |
| 1111 | 1 |
| 888 | 8 |
| 44 | 4 |
| 2 | 2 |
| | 8 |
| 446614 | 3 |

Which, being transferred to the *Denary Scale*, gives 267313 for the quotient of the original number by *eight*.

DENARY SCALE.

| | |
|---|---|
| 222222 | 2 |
| 11111 | 1 |
| 3333 | 3 |
| 888 | 8 |
| 55 | 5 |
| | 7 |
| 237611 | 8 |

Which expresses the quotient of 2138507 by *nine*.

DUODENARY SCALE.

| | |
|---|---|
| 88888 | 8 |
| 7777 | 7 |
| 111 | 1 |
| 66 | 6 |
| 8 | 8 |
| | ⅋ |
| 94609 | 8 |

Which, converted into a Denary expression, is 194409, the quotient of the original number by *eleven*.

But the extension which was made of the same principle to open counters, may be applied to discover the quotient and remainder of any number divided by the index of the next higher scale. Not to dwell on this subject, we shall take only three of the last examples to illustrate the mode of operation. Beginning at the left hand, each figure must be repeated through all the succeeding places, alternately as an excess and a defect, and the balance of addition taken as the result. The same as 720053; which being transformed to the *Denary Scale*, gives 237611, with a remainder of 8 for the quotient of 2138507 by *nine*, the index of the scale augmented by one.

OCTARY SCALE.

| | |
|---|---|
| 111111 | 1 |
| 11111 | 1 |
| 2222 | 2 |
| 62 | 6 |
| 1 | 1 |
| | 3 |
| 1120065 | 8 |

The same as 194409; which is the quotient of the original number by *eleven*, the remainder of the division being 8.

DENARY SCALE.

| | |
|---|---|
| 22222 | 2 |
| 11111 | 1 |
| 3333 | 3 |
| 888 | 8 |
| 55 | 5 |
| | 7 |
| 214411 | 8 |

DUODENARY SCALE.

| | |
|---|---|
| 88888 | 8 |
| 7777 | 7 |
| 111 | 1 |
| 66 | 6 |
| 8 | 8 |
| | ⅋ |
| 81244 | 7 |

This amount is the same as 7⅋244; which, transferred to the *Denary Scale*, makes 164500 for the quotient of the original number by *thirteen*, the remainder of the division being 7.

Casting out Nines, Elevens, &c.

It is of more consequence, however, in such divisions, to discover the remainder than the quotient. If the process be confined to the *Denary Scale*, the number *eleven* will appear to have properties analogous to those of *nine*. But to find the remainder of the division of any number by *eleven*, or, in the vulgar phrase, *to cast out the elevens*, will require attention to the alternate character of the ciphers, fluctuating in succession from excess to defect. The easiest mode is, beginning at the right hand to mark the alternate figures; and, from the amount of these, augmented by eleven, if necessary, take that of the rest, and the difference is the remainder sought. Thus, resuming the original number 2′13′85′07′, the sum of the marked figures is 17, and that of the rest only 9; wherefore, if divided by eleven, it would leave an excess of 8. Again, taking the number 52′90′46′82′, the marked figures together make only 10, while the others amount to 22; the former must consequently be augmented repeatedly by the addition of eleven, till the sum 32 comes to exceed 22. The remainder of this division would therefore be 10.

It hence follows, that, as a number is divided by *nine* when the amount of its figures is any multiple of *nine;* so a number is divisible by *eleven*, when the sums of the alternate figures are either equal or differ by *eleven* or its multiples. This proposition leads to some curious results; but we shall notice only the more striking and simple. It is an obvious consequence, that the *difference* between any number and its reverse is divisible by *nine:* Thus, the number 2138507 being reversed into 7058312, gives the difference 4919805, divisible by 9. The reason is plain, since this number and its reverse are expressed by identical figures, they are both multiples of 9 with the same excess, and consequently their difference must only be some multiple of 9. Again, the *difference* between a number and its reverse is likewise divisible by *eleven*, if it consists of odd figures: Thus, the last difference 4′91′98′05′ is divisible by 11, for the sums of the alternate figures are each 18. But the *sum* of a number and its reverse is divisible by *eleven* when it consists of even figures. Thus, the number 52904682 has 28640925 for its reverse,

and their sum is 81′54′56′07′; which is evidently divisible by 11, for each set of alternate figures amounts to 18. It is not difficult to perceive the reason of these properties of *eleven;* when the number consists of odd figures, they preserve the same character of abundant or defective in its reverse, and consequently the subtraction of the opposite numbers will destroy whatever inequality there had before existed; but when the number proposed consists of even figures, the abundant and defective by reverting change mutual places, and hence the sum of the number and its reverse will extinguish any original inequality between these, balancing any surplus of the one set by the equal deficiency of the other. Thus, in the first example, the number 2′13′85′07′ exceeds by 8 a multiple of 11, and so does its reverse 7′05′83′12′, the marked figures being the same in both; consequently their *difference* is a multiple of 11. In the second example, the number 52′90′46′82′, is greater than a multiple of 11 by 10, and its reverse 28′64′09′25′ is greater than another multiple of 11 by 1, or is less than the next lower multiple by 10: Wherefore these opposite numbers added together will produce a mutual balance accurately divisible by 11.

The *casting out* of the nines and elevens, furnishes a ready, though but a negative proof of the accuracy of arithmetical operations. In addition, for instance, by casting the nines or elevens out of each number, and collecting those excesses, the result of another ejection should be the same as from the sum. This principle applies equally to subtraction; but the mode of proceeding in multiplication and division will require some investigation. By casting the nines out of a number, it is converted into the *Nonary Scale*, of which the excess would occupy the place of units; if another number, therefore, were treated in the same way, and their product represented on that scale, that part of it formed by multiplying the excesses would still retain the rank of units, and exhibit the remainder of the division by nine. The same principle, it is obvious, will extend to the casting out of eleven.

Thus, in the first example of compound multiplication, the nines, being cast out of the multiplier, and multiplicand, 472 and 3809, leave 4 and 2, which produce 8, the remainder of the division of the product 1797848 by 9. In like manner, on casting eleven out of the former numbers, there are left 10 and 3, which being multiplied yield 30, or an excess of 8; but the product 1797848 divided, by 11, leaves also 8. Again in the next example, if nine be cast out of the multiplier and multiplicand, 6428 and 36985, there remains 2 and 4 as formerly, and their product 8 is excess of 237739580 above the nearest multiple of nine. With eleven likewise the remainders are 4 and 3, whose product 12 gives an excess of 1 for the remainder of the division of the result by eleven.

In the *Duodenary Scale*, the corresponding property must belong to the numbers *eleven* and *thirteen*. Thus, in the first example, *casting the elevens* out of 276 and 2957, the excesses are 4, and 1; but their product 73ɸ1ɸ6 being divided by *eleven*, leaves 4. *Casting thirteen* out of the same factors, there remain 1 and 9, and the product, divided by *thirteen*, leaves 9. Again, the second example, *casting out the elevens* from 3878 and 194ɸ1, there are left 4 and 3; which being multiplied give 12, or 1 for the excess of the product 67′75′09′38 above the nearest multiple of *eleven;* but *casting thirteen* out of the same numbers, the remainders are 6 and 9, which give 54 or 10 for the excess of the product.—The agreement in these examples affords a strong presumption of the correctness of the operations; as any discordance would be an absolute proof of inaccuracy.

Transferring of Scales.

To transfer any numeral expression from one scale to another, the most obvious way, is, to decompound it and then dispose it again on the new scale. Suppose it were required to convert the binary expression 1000011001 into another on the *Quinary Scale.*

Beginning at the left hand, and constantly doubling the terms, shifting them every time a place lower, the successive results are 2, 4, 8, 16, 33, 67, 134, 268 and 537. This number again, if decomposed by a series of *pentads*, gives 4122 for its *Quinary* expression. But the conversion might be performed directly with more expedition, by dividing the original expression successively by the root of the new scale.

```
5)537
  107 2
   21 2
    4 1
```

The operation would be conducted thus:

BINARY SCALE.

```
101(           101)        101)   101)100
   )1000011001(1101011(10101(
    101         101        101
    110          110       001
     101         101
      111         111
      101         101
       1000        10
        101
         111
         101
          10
```

The divisor 5 being denoted on the *Binary Scale* by 101, the repeated analysis is pursued on the same scale; the series of inverted remainders is 100, 1, 10, and 10, giving, as before, the final result 4122 on the *Quinary Scale.*

Let it be sought to convert this last expression to the *Ternary Scale*, the division will be performed in this manner:

```
3)4122
  1204 0
   214 2
    34 2
    11 1
     2 0
```

The Ternary expression is hence 201220.

To reduce vulgar fractions to any scale, we have only to multiply the numerator by the root of that scale, and to divide the product by the denominator, and to repeat this process till it either terminates or glides into a circulation. The series of quotients exhibits the value developed on the descending bars. But this decomposition has been already anticipated.

Figurate Arithmetic.

The same method applies likewise to the conversion of mixed fractions. Suppose it were sought to express fifteen shillings and three pence three farthings on the *Denary Scale* of pounds. Multiply this sum repeatedly by ten, and the integral results deferred to the lower bars, must evidently express the same value. The corresponding decimal is hence .765625, as formerly employed.

```
      15   3¾
           10
L.7   13   1½
           10
L.6   11   3
           10
L.5   12   6
           10
   L.6     5
           10
   L.2    10
          10
     L.5
```

This example, however, is better adapted to the *Duodenary Scale*, the multiplication being performed by successive twelves. The duodecimal expression for the same sum is therefore .923, consisting of only three figures.

```
      15   3½
           12
L.9   3    9
           12
   L.2     5
           12
     L.3
```

These reductions might be performed differently, by ascending gradually to the higher denominations; the farthings being changed into parts of a penny, the pence into parts of a shilling, and the shillings into parts of a pound.

DENARY.

```
4)3      12)3.75      20)15.3125
 .75        .3125        .765625
```

This process requires no farther explanation; but, in the *Duodenary Scale*, it becomes expedient to represent the 12 and 20, by 10 and 18.

DUODENARY.

```
4)3      10)3.9      18)13.39
 .9         .39          .923
```

To transfer the expression of a fraction from one scale to another, it should be multiplied successively by the root of this, and the integral results retained. Thus, to convert the decimal fraction 7854, which expresses the relation of the circle to its circumscribing square, to the *Duodenary Scale*: Multiplying the whole by twelve, the product would represent on the next bar of this scale the same value; again, the fractional surplus .4248 being multiplied by twelve, gives another residue for a lower bar; and this process being continued, the fraction proposed is at last changed into the duodecimal .9512, being the number already employed in the mensuration of circular timber.

```
 .7854
    12
9.4248
    12
5.0976
    12
1.1712
    12
2.0544
```

Again, suppose it were required to transfer the expression .2132032, from the *Quaternary* to the *Ternary Scale*: This operation will be performed by continually multiplying the fractional part by three, and retaining only the integral results. The value of the expression is, therefore, on the *Ternary Scale*, denoted by .12121122, &c.

```
 .2132032
1.3122222
2.2033332
1.2233322
2.2033232
1.2232022
1.3322132
2.3233122
2.3032032
```

Figurate Arithmetic.

Extraction of Square Root.

The finding of roots is a branch of Arithmetic, to which the system of numerical arrangement is well adapted. The method of proceeding here, is to approach by successive steps to the final result, descending from the highest to the lowest point of the given scale, by discovering the series of additions required to complete the number sought. The extraction of the square root, is the easiest and the most important. To investigate the principle which should direct this operation, we must examine what takes place in the process of compound multiplication. If a number composed of two parts be multiplied into itself, the result will evidently consist of the squares of those parts, together with twice their mutual product. Now, taking away the square of one of these parts, suppose the greater, there must remain the square of the other, joined to their double product; or, what is the same thing, this residue will be the product of the smaller into a number formed by annexing it to double the greater. Consequently, to discover the secondary or additive portion of the root, we have only, after the square of the principal part has been separated, to divide what is left, by twice its root, annexing always the quotient to this divisor, in closing the process of division. The same operation, descending successively to lower terms, must be repeated, till the number proposed for extraction be entirely exhausted. It is only requisite to observe the rank and number of the figures which the root should contain. But, for this purpose, since every compound number will evidently by squaring have its places of figures doubled, we need only distinguish each pair in the number whose root is sought.

An example will best explain the whole procedure. Suppose it were required to find the square root of 107584. Beginning at the right hand, and marking every second figure, it is divided into three periods; which shows that the root must consist of hundreds, tens, and units. To the first period 10, the nearest square is 9, whose root 3 must occupy the place of hundreds. Subtracting and taking down the next period, the residue 175 comes to be decomposed; doubling, therefore, the root, we have 6 in the place of hundreds, to which the quotient 2, as denoting *twenty*, is annexed, and the product 124 set down for subtraction. The remainder, with the last period, making 5184, is finally to be analysed. Twice the root already found, amounting to 640, with the quotient 8 itself, forms the new divisor, and the product extinguishes what was left of the proposed number. The root is therefore 300, with the successive additions of 20 and of 8.

DENARY SCALE.

```
     107584(328
     9
  62)175
   2)124
 648)5184
   8)5184
        0
```

It will sometimes be convenient, in performing this operation, to employ deficient figures, especially as they will rectify the oversight, in case too large a quotient may have been assumed.

```
     1124224(332
     9
  63)224
   3)
 662)21324
   2)21324
```

We subjoin an example of the

extraction of the same root on the *Duodenary Scale*. This practice will often be found useful in mensuration.

```
52314(234
4
43)123
 3)109
464)1614
  4)1614
       0
```

To elucidate this subject fully, we shall likewise exhibit the same extraction carried through the inferior scales.

BINARY.

```
1101001000100000(10100100
1
1001)1010
   1)1001
1010001)1010001
      1)1010001000000
```

TERNARY.

```
12110120121(1100
1
2112
1121
22001)101201
    1) 22001
220021)220021
     1)220021
```

QUATERNARY.

```
122101000(11020
1
21)22
 1)21
2202)11010
   2)11010
        00
```

QUINARY.

```
11420314(2303
4
43) 242
 3) 234
10103)30314
    3)30314
          0
```

The same mode of proceeding will obviously extend to the descending terms of any scale, a pair of zeros being annexed to the remainder after each successive division. As an example, we shall select the calculation of the greater segment of a line, divided by extreme and mean ratio, which is denoted by $\sqrt{\frac{5}{4}}-\frac{1}{2}$, the whole being unit. The radical is thus found on three different scales.

QUATERNARY.

```
1.10(1.013203
1
201)1000
  1) 201
2023)13300
   3)12201
20322)103300
    2)100300
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DENARY.

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DUODENARY.

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1.30(1.14φφφφ7
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228φ)22800
   φ)20621
2291φ)219φ00
    φ)207101
229φφ7)129φφ00
     7)1379φ21
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It hence appears, that the greater segment of a line, divided by extreme and mean ratio, is expressed in duodecimals by .74φφφ7, or extremely nearly by .75; and, therefore, that it consists of 89 parts, of which the whole contains 144. The very same result is obtained from the recurring series, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, &c. which continually approximates to the required value.

The main advantage of this scale, consists in its fitness to denote fractional parts. Its root has indeed no fewer than four factors — 2, 3, 4, and 6; while *ten* is divisible only by 2 and 5. Several attempts, accordingly, have, at different times, been made to carry the *Duodenary Scale* into actual practice. It is a singular fact, that the famous Charles XII. of Sweden, whose views, though often disturbed by the wildness of heroism, were on the whole beneficent, seriously deliberated on a scheme of introducing this system of numeration into his dominions, a very short time before his death, while lying in the trenches, during the depth of winter, before the towering Norwegian fortress of Fredrickshall.

With respect to square numbers, it may be remarked, that they terminate only in these five digits,—1, 4, 5, 6, and 9,—which lie equally distant on each side of the middle. When a number ends in 1, its square root must end in 1 or 9; when it ends in 4, the root ends 2 or 8; when it ends in 5, the root will likewise end in 5; when it ends in 6, the root will end in 4 or 6; and when it ends in 9, the root will end in 3 or 7. Unless, therefore, in the case of 5, there are always two corresponding terminations of the root, making together the number *ten*.

Cube numbers, or those denoting the third powers, and produced by a triple multiplication, are not affected by such ambiguity. They have for their terminations indiscriminately all the nine digits. If any cube should terminate in one of the fore-mentioned figures, 1, 4, 5, 6, or 9, its root will end in the same figure; but if it terminate in any of the remaining digits, 2, 3, 7, or 8, the corresponding root will end in 8, 7, 3, or 2, that is, in the difference of each from *ten*.

But we have already far exceeded our limits, and must abruptly conclude. Still we should commemorate, though not in the proper place, one of the earliest and ablest writers in England on Arithmetical Science;—Robert Recorde, Fellow of all Souls, Oxford, and Doctor in Physic, published in 1540 a treatise of Arithmetic, in the form of a dialogue. * He afterwards proceeded farther; and, in his *Whetstone of Witte, containing the Extraction of Rootes and Cosike practise*, he introduced the first rudiments of Algebra. But this benefactor of his country, who seems to have devoted himself to the teaching of Mathematics in London, was treated with ingratitude, and, to the disgrace of the age, left to struggle with chilling poverty, and constrained to end his days in the gloom of a prison. (D.)

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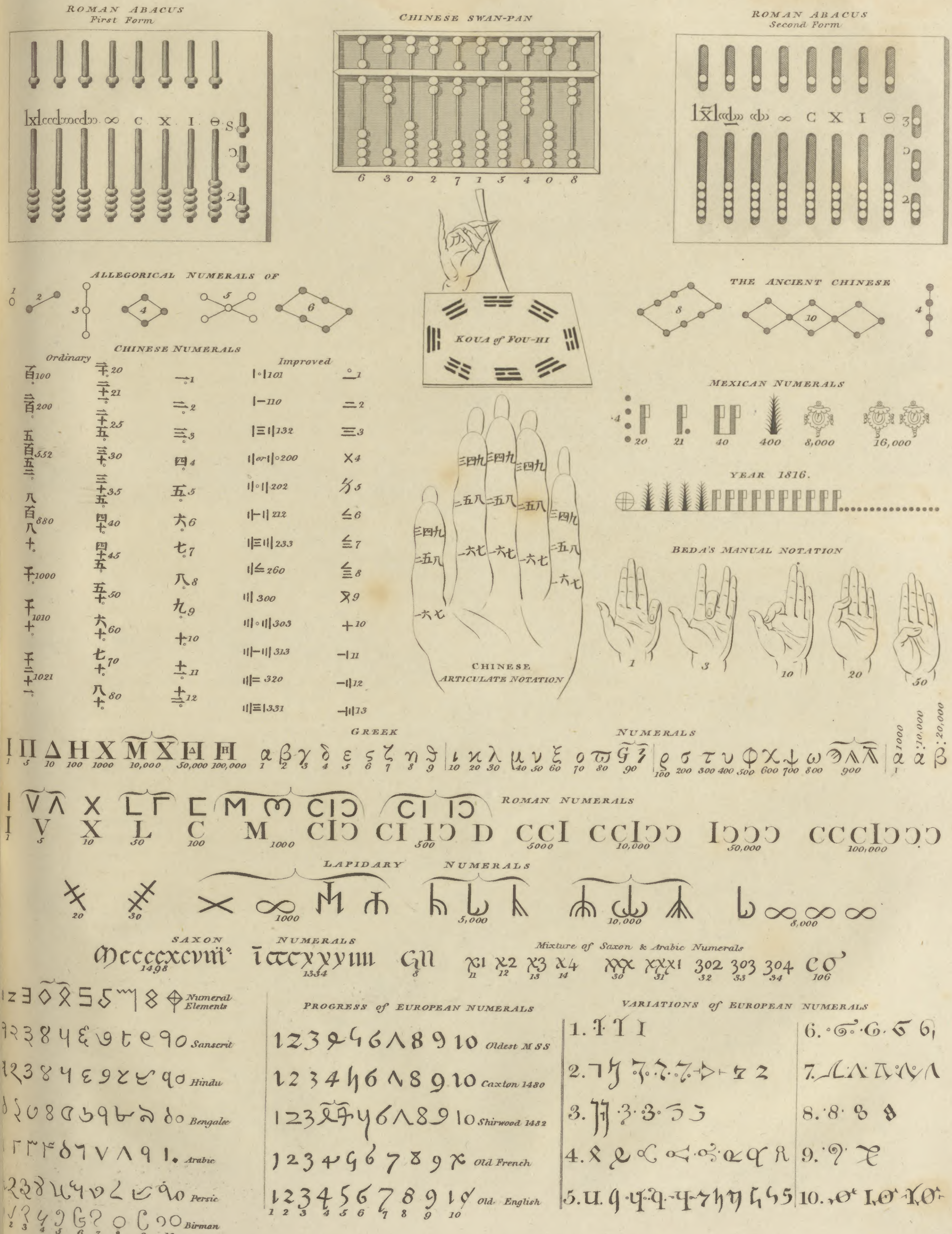
* We subjoin another specimen of the Roman or Saxon numerals till then used: In the accounts of the Scottish Exchequer for the year 1331, the sum of L.6896, 5s. 5d. stated as paid to the King of England, is thus marked, vj$^{m}$. $\overset{c}{\text{viij}}$. $\overset{xx}{\text{iiij}}$. xvj. ŧj. v. š. v. đ. It may be observed, that, in Scotland, the contraction ʒ$^{m}$ for *one thousand*, is still used in the dates of charters, and other legal instruments.




Drawn & Engraved by W. & D. Lizars Edin.r

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Armagh.

Extent and Boundaries.

ARMAGH is an inland County in Ireland, in the Province of Ulster; it is bounded by the waters of Lough Neagh on the north; by the Counties of Monaghan and Tyrone on the west; by the County of Lowth on the south; and by the County Down on the east. Its figure is that of an irregular oblong; its length, from its northern to its southern extremity, is about 32 English miles; and its breadth, nearly 20 miles. Its area comprises 290,786 acres, or about 454 square English miles. It is divided into five Baronies, and comprises 20 Parishes. The principal Towns are, Armagh, Charlemont, Market-hill, Blackbank, Jonesborough, and Portadown.

Archbishoprics.

Armagh is the metropolitan see of Ireland. The Province of the Archbishop is the largest in the Island, containing ten Dioceses, viz. the Archbishopric of Armagh, and the Bishoprics of Dromore, Down and Connor united, Derry, Raphoe, Clogher, Kilmore, Ardhagh (which, though in this Province, is at present annexed to the Archbishopric of Tuam), and Meath. The Archbishopric extends into five Counties, viz. Armagh, Londonderry, Lowth, Meath, and Tyrone, being 59 miles from north to south, and varying in breadth from 10 to 25 miles. Its annual value is about L. 8000.

Face of the Country.

The face of the country is in general interesting; but in the southern part there is a chain of black and nearly uncultivated mountains called the Fews, thinly inhabited. On the borders of Newry-water, there is also a small range called the Fathom and Newry mountains. Near the banks of Lough Neagh, and along the rivers, the country becomes beautifully champaign, though even here there are extensive mosses. The soil of these mosses is remarkably black, and extends to a great depth.

Rivers.

There are several small streams which rise in the interior of this County, most of which fall into the rivers which wash its confines. The Blackwater, which continues the navigation of the coal canal to Lough Neagh, and divides this County from Tyrone, is enlarged on its entrance into Armagh, by the waters of the Tynan, Tall, and Callen. The Cushier, which rises in the interior, and the Camlough, which issues from Lake Camlough, supply the Newry canal on the eastern boundary of Armagh. In the southern part of the County, the Tara, Newlin, Hamilton, and Fleury waters rise, which, after various windings, enter Lowth County, and fall into the bay of Dundalk. The principal lakes are Lough Neagh, Camlough, and Lough Clay.

Lough Neagh.

Lough Neagh covers a great area in the Province of Ulster, washing parts of the Counties of Antrim, Armagh, Down, Londonderry, and Tyrone. Its extent, however, is ascertained by actual survey, not to be much more than one half of what it was formerly conjectured to be. It is 15 miles in length, and 7 in breadth, and covers 58,200 acres. Seven rivers, and a very great number of smaller streams, run into it, whereas the Ban is the only outlet for its waters. It is by no means a beautiful lake; its banks, for the most part, being low and marshy, and incapable of being drained; and, where bold and abrupt, entirely destitute of wood. There are but two Islands in it: Ram Island, already mentioned in the article Antrim; and another near the shore, in the south-western angle of the lake, called Blackwater Island. A great variety of fish are found in Lough Neagh: salmon, a large kind of trout, bream, perch, and the pollen, which is the same as the *ferra* of the Lake of Geneva, and the *gwyniad* of Bala Lake in North Wales. On some parts of the Antrim shore, its waters possess a petrifying quality, arising either from the water itself, or more probably from some parts of the soil dissolved in the water.

Minerals.

Marble of an excellent quality, and of great beauty, is wrought in Armagh. Its other mineral productions are neither numerous nor important. There are some lead mines, the property of the Earl of Feversham; but they are not at present wrought. In the abrupt stratified banks of the Callen, there are indications of lead, manganese, and other minerals. The lime strata in the vicinity of Armagh approach to what is called *plum-pudding stone*.

Climate.

The climate is mild, considering the latitude, except in the mountainous parts. The mean temperature, in the neighbourhood of the town of Armagh, about 25 miles from the Irish Channel, and elevated about 58 feet above the sea, ascertained by means of a well 6 feet deep, was $47^{0}$ 5.

Landed Property.

Estates in this County are not large; there being only seven or eight proprietors who possess them of the annual value of from L. 6000 to L. 10,000. The farms also are small, being commonly from 5 to 20 acres, and seldom exceeding 40 or 50. From the return of registered freeholds in Ireland, it appears that, in March 1815, there were, in this County, 6053 persons who possessed freeholds of the value of 40s. 120 who possessed freeholds of the value of L. 20, and 144 who possessed freeholds of the value of L. 50.

Agriculture.

Neither the arable nor the pasture husbandry of this County present much that is worthy of notice. Potatoes, flax, and oats, are the chief produce of the arable districts; and those are cultivated in a very rude and inferior manner, in consequence of the ignorance of the farmers, and their want of capital. The quantity of seed used, and the average crop, are nearly the same as those stated in our account of the agriculture of Antrim. But there is a much larger proportion of land under flax in this County; for, in the year 1809, there were 15,000 acres sown with it in Armagh, while there were only 11,000 acres in Antrim. A few acres of hemp were also sown.

Cattle and Sheep.

There are no extensive dairy-farms in Armagh, nor are there any farmers exclusively in this branch of husbandry; nevertheless a considerable quantity of butter is made here. One hundred weight per cow is considered as the average produce. The proportion of milch cows to the size of the farms, is, on small farms under five acres, one cow; on farms exceeding five, and under ten acres, perhaps two cows, seldom more. A considerable number of cattle are reared. From the low country they are sent to the mountain farms, and frequently afterwards sold in the Scotch market. They are in general of a small stunted breed. The native sheep are an awkward breed; the wool coarse, and in small quantity; very little of it is exposed to sale, there being hardly sufficient for domestic use. Goats, swine, and poultry abound. Wild geese, swans, wild ducks, and several

Armagh.

other species of aquatic birds, are indigenous to the lakes and rivers. Formerly bees were much attended to, but at present they are neglected.

Roads.

The roads in general are bad; and, what is extraordinary, the turnpikes are the worst, and the cross roads the best. A canal has been cut from Coal Island to Armagh, but it is little used.

Manufactures.

The principal manufacture is that of linen, which forms the chief employment of the inhabitants; and the annual average value of which is estimated at L. 300,000. This manufacture is very extensively carried on in the vicinity of the city of Armagh. Bleachfields are numerous on the banks of the Callen. Woollen goods are made only for home consumption.

This County returns two representatives to the Imperial Parliament; and the city of Armagh one. It is in the north-east Circuit; the Assizes are generally held in the middle of July.

Population.

The mountainous parts of Armagh are entirely inhabited by Roman Catholics; and it is estimated, that one half of the inhabitants in the other parts are of the same persuasion: so that the Protestants cannot constitute more than one third of the population. Of the other dissenters from the established religion, the Presbyterians and Burghers are the most numerous.

The number of houses, according to the last returns, is 22,900: of which 18,794 have only one hearth; 784 two hearths; 217 three hearths; 105 four hearths; 75 five hearths; 31 six hearths; 28 seven hearths; 21 eight hearths; 15 nine hearths; 8 ten hearths; and 23 more than ten; and four of them forty-four hearths. The population, reckoning $5\frac{1}{2}$ inhabitants to a house, will be about 130,000; which gives 78 people to an Irish square mile. There are rather more than eight Irish acres to a house.

Customs.

In some districts of this County, hunting is a favourite amusement with the weavers; the hounds are not kept in packs, but distributed over the County, one being generally kept in each cabin. On the day appointed for the chace, the looms are deserted. In a County where the land in general is parcelled out into such small divisions, it would not be practicable for the gentlemen to pursue this diversion on horseback; and therefore the game is relinquished to the weavers. The dog they employ on these occasions is a dwarf fox-hound, in a degree similar, either to the English beagle, or the southern slow-hound, still used in the hilly districts of Sussex and Kent. The farmers of Armagh are noted for their fondness for jockeying, in all the arts and tricks of which they are expert to a very criminal degree.

School of Armagh.

The school in the city of Armagh is one of the royal foundations of Charles I., and is very well endowed; for, according to the report of the *Commissioners of the Board of Education*, the lands which belong to it contain 1530 acres, English measure, besides about 100 acres of bog. They are situate in the County, between the towns of Newry and Armagh. In the year 1804 the gross annual rent was L.1144, 10s. $5\frac{1}{2}$d. There are generally upwards of 100 boys educated at it. The school-house was built by Lord Rokeby, better known by the name of Primate Robinson.

Armagh ‖ Arreoys.

The County of Armagh is celebrated both in civil and religious antiquity. In the early annals of Irish history, it is mentioned as the seat of their monarchs. Turgesnis, the first Norwegian Prince that obtained a footing in this kingdom, established his capital here. A tribe of Danes, called Ostmen, for a considerable time afterwards, formed the chief inhabitants of the County. Most of the present inhabitants are descended from the Scotch. See Wakefield's *Ireland*. Barton's *Natural History of Lough Neagh*. *Statistical Survey of Armagh*, by Sir Charles Coote. (c.)

ARMY. See the *Encyclopædia* under that head, and Tactics in this Supplement.

ARNAUD DE RONSIL (George), son of an eminent surgeon, at Paris, and some time Professor of surgery in the College of St Côsme. On account of an accident that occurred while he was practising midwifery, he removed from Paris to London, where he acquired great repute by his operations, and his writings on surgical subjects. Before his time, the treatment of *hernia* had been but imperfectly understood; and the surgeons of this country are indebted to the observations of Arnaud for many of those improvements which have since rendered their practice so successful in this branch of the art. The following is a list of his principal works: 1. *Traité des Hernies ou Descentes*, 2 vols. 12mo. Paris, 1749. 2. *Observations on Aneurysms.* London, 1750. 3. *Instructions on the Diseases of the Bladder and Urethra.* London, 1763. 4. *A Dissertation on Hermaphrodites.* London, 1750. These were afterwards collected, and published, with additions, under the title of *Mémoires de Chirurgie, avec quelques Rémarques sur l'etat de la Medicine, et de la Chirurgie en France, et en Angleterre*, 2 vols. 4to. London, 1768. 5. *Remarks on the Use of the Extract of Lead of Goulard.* London, 1776. Arnaud died in 1774. (E.)

ARRAN. See Arran in the *Encyclopædia*, and Buteshire in this Supplement.

ARREOYS. Among the more singular Secret Societies which mankind have formed, is one in Otaheite and the neighbouring Islands, for the destruction of their own species, called *Arreoy, Arehoe, or Earowie;* and it is not a little remarkable, that it should subsist among tribes distinguished for courteousness and humanity. We read in the older authors, that there is an absolute prohibition against the females of Formosa rearing children before the age of thirty-six, though it does not appear that there is any limitation as to the age at which their espousals may take place. But, in the event of pregnancy, it is necessary that abortion should follow, which is accomplished by the aid of the Priestesses of the Island. Among the Arreoys, however, extirpation of the infant being constitutes the leading feature of their ordinances.

Whether Mendana, Quiros, and the earlier navigators of the South Pacific Ocean, discovered this society, does not appear; it has, at any rate, been reserved for those of later date to unfold its principles and peculiarities; though, indeed, its constitution is still enveloped in much mystery, the members being bound to the strictest secrecy.

Arreoys. The society of Arreoys consists of hundreds or perhaps thousands of both sexes, who engage to destroy their own offspring at the moment of birth. It is chiefly composed of persons distinguished by valour and merit, and hence, one or more individuals of each family of the chiefs are of the number. It has been remarked, that all the men profess themselves warriors, and are in general stout and well made; that the greatest trust and confidence are reposed in them; and it rather appears, that the women consist of the higher ranks only. There are different gradations in this community, which are to be recognised from the mode of tattooing; the more profusely the men are tattooed, the higher is their rank in the society; the first are called *Ava bly areema tutowe; 2. Areema bly; 3. Ahowhoa; 4. Harrotea; 5. Eote ole;* 6. 7. *Po;* and youths training up are designed *Mo;* but the meaning of these names is not explained. By the fundamental laws of the society, the offspring must be destroyed; yet it is not known with certainty by whom or in what particular manner; the murder is always perpetrated in secret, probably by strangulation; all the attendants are excluded; for it is said, were they to witness it, they would be adjudged guilty of participation, and themselves be put to death. Sometimes the mother, animated by natural affection, tries to preserve her infant, and resists the persuasions of her husband, and his brother Arreoys, who wish to consign it to destruction. But in general the enormity of the crime does not appal the females, though they are described to be affectionate and tender. We find a dancing girl pregnant by an Arreoy, expressing herself thus to the English navigators: "Perhaps the *Etooa* or deity of England, might be offended with the practices of the Arreoys, but her own was not displeased with it. However, she promised, if we would come from England for her child, she might perhaps keep it alive, provided we gave her a hatchet, a shirt, and some red feathers." That the rules of the community are very strict, may be inferred from an instance given by Captain Bligh. A chief, a member of the society, married a sister of the king of Otaheite, by whom he had eight children, and the whole were destroyed at their birth! Nor did this enormity seem to originate from any other source, as the parents afterwards adopted a nephew as their heir.

It may here be observed, that there are other practices among these people regarding infanticide, which, though we want materials for positively affirming the fact, may perhaps be connected with the institutions of the Arreoys. When an Otaheitan chief has a child by a woman of the lower orders, it is never suffered to live, and the like seems to take place reciprocally among the higher ranks of females. The King and Queen of Otaheite having ceased to cohabit, he had taken another wife, and she associated with one of her attendants of low rank. When pregnant, the missionaries endeavoured to persuade her to spare her child, which she said she would have done, had it been her husband's, but now it would be base born, and must perish; and she resisted all entreaties to the contrary. Afterwards, having visited them, she excused herself for having put the infant to death; stating that it was the custom of the country to murder all base-born children, and hers being by a low man, she had only complied with the usual practice. Indeed, it is affirmed by the Missionaries who visited that Island in 1797, to be a common proceeding among all ranks, to strangle infants the moment they are born. "A perpetrator of this horrid act," the narrator observes, "was among those whom curiosity attracted to visit us. She was a good-looking woman, and esteemed by the natives a great beauty, which I suppose to be the inducement that tempted her to murder her child; for here the number of women bearing no proportion to the men, those esteemed handsome were courted with great gifts, and got so accustomed to change their husbands, to go with them from place to place, and run after the diversions of the Island, that rather than be debarred those pleasures, they stifle a parent's feelings, and murder their tender children." Thus many hundreds born into the world are never suffered to see the light; and so little criminality in the opinion of the natives is attached to the deed, that many women disclose the number they have put to death, without scruple. It has been calculated, that at least two-thirds of the births on the Island perish in this manner.

Arreoys. The Arreoys enjoy great privileges, and are everywhere united by the reciprocal ties of friendship and hospitality. When they visit different Islands, they receive presents, and are entertained with feasting and dramatic exhibitions; and all this they seem to expect rather as a matter of right than of courtesy. Their clothes are of the finest materials. They pass their time in luxurious idleness, perfuming their hair with fragrant oils, singing and playing on the flute, and passing from one amusement to another. "Wherever they go," says Forster, "the train of sensual pleasure awaits them." They feast on the choicest vegetables; and an abundance of dogs flesh and poultry are liberally provided by the lower classes for their entertainment. They are copiously supplied with *kava,* and for them are performed nocturnal sports of music and lascivious dances, to which no other spectators are admitted. Their presence seems to enliven the whole country; and among the various entertainments to which it gives birth, is one called *hopowpah,* of a dramatic nature, in which they themselves act a part. As soon as one Arreoy visits another, though a stranger, he immediately has his wants supplied and his wishes gratified; he is introduced to other members, who vie with each other in loading him with courtesies and presents. They are of all others the most luxurious and profuse, often consuming the whole provisions of a district. When Captain Cook lay at Huaheine, no less than 70 canoes were observed crossing over to another Island, with 700 Arreoys on board; and thus they keep great meetings at appointed times, and travel in companies from one Island to another. It has been affirmed, but perhaps without sufficient foundation, that a promiscuous inter-

Arreoys. course of the sexes prevails in their society; however, they are permitted great latitude in their amours, except in times of danger, as almost all are fighting men. Sufficient inducements are therefore held out to be admitted into this mysterious community.

Any one may withdraw at pleasure from the society; and an example is given of a chief who had killed his first-born child, but preserved the second, having withdrawn in the interval. A woman who ceases to be an Arreoy, incurs a reproachful name, signifying "bearer of children." Thus, while in most other countries the name of parent confers honour and respect; among the Arreoys of Otaheite, it is used as a term of contempt and reproach. A Chief of some repute, hearing that the King of Great Britain had a numerous offspring, he declared that "he thought himself a much greater man, because he belonged to the Arreoys."

With respect to the origin of this society, Forster was the first to offer any conjectures. "In a country," says he, "which has emerged so lately from barbarism as Otaheite, we cannot suppose that such a community, which is evidently injurious to the rest of the nation, would have maintained itself to the present time, were not its advantages so considerable as to require its continuance." There are two causes, he adds, which favour the existence of the Arreoys: first, the necessity for entertaining a body of warriors, to defend their fellow-citizens from the invasions and depredations of enemies. Secondly, it was necessary by such an association to prevent the too rapid increase of the number of their chiefs. "Perhaps," he remarks, "some intelligent Otaheitan lawgiver might foresee, that the common people would at length groan under the yoke of such petty tyrants, whose number was ever multiplying." The ordinary practice of infanticide is ascribed by Mr Wilson, who visited the South Seas in 1801, merely to the love of pleasure and avarice, which latter passion had gained great ascendancy since the intercourse of the Islanders with Europeans; "being well aware," says he, "that the beauty of females rearing families experiences an earlier decay, it is anxiously preserved for their visitors, by destruction of their offspring, or even by procuring abortion." Before offering any opinion on this point, we shall notice a custom in the North West of India, somewhat analogous, which also is attended with mystery.

Amongst certain tribes called Jarejahs, which are more particularly disseminated in the peninsula of Guzarat, the whole females are devoted to death at the moment of their birth. But this is in consequence of general custom, not of any special association. The immediate death of a daughter is viewed as the inevitable consequence of its birth; and the innocent beings falling a sacrifice to this barbarous ordinance, yearly amount to many thousands. When a woman is delivered of a daughter, the event is communicated to the father by the female attendants, who desires them to do as is customary; an injunction said to be followed by the mother applying a little opium on the nipple of her breast, which is sucked in by the child. More usually it is strangled by herself, or drowned in a basin of milk; but women of rank, who have attendants, never perform the office themselves. However, from the mystery observed, it is, as among the Arreoys, difficult to obtain correct information. In some districts, any of the female attendants may put the infant to death; in others, a kind of domestic Priest becomes the executioner; and the infant being placed naked in a small basket, it is carried out to be interred, for which he receives a trifling fee. Among the Arreoys, those who preserve their children seem to suffer a degree of degradation, and they plead as an apology for their destruction, that it is necessary to preserve the privileges of their tribe. With the Jarejahs, the father is obeyed on signifying his desire for preservation; but if he continue silent on receiving the intelligence, the usual custom must be complied with. The mother is generally averse to the sacrifice, but her scruples to preserve her offspring are seldom attended to; should a short interval elapse, however, before the bloody deed is done, it then becomes unlawful, and the child must be spared.

In India, it is said that mothers who had been long barren, offered their first born as a sacrifice to the gods, either by leaving it in the woods to be devoured by beasts of prey, or by throwing it into a river. But, in progress of time, a commutation took place, by devoting the victim to the service of some temple, from which it might be redeemed. The ancients were profuse of human blood to gratify their Deities, and even without the particular cause just alluded to, children were especially doomed to be offered in sacrifice. In times of public calamity, an only child was deemed the most acceptable sacrifice: as being more precious to its parents, its death was supposed of greater efficacy in purchasing expiation. "And when the king of Moab saw that the battle was too hot for him, he took with him seven hundred men that drew swords, to break through even unto the king of Edom; but they could not. Then he took his eldest son, that should have reigned in his stead, and offered him for a burnt offering upon the wall." Nothing can be more precise than this passage of Scripture, as to the fact of a parent sacrificing his eldest child, in case of a grievous extremity; and there is also another passage, though more obscurely expressed, to the same purport, where the offering is in atonement. "Wherewith shall I come before the Lord, and bow myself before the High God? Shall I come before him with burnt offerings, with calves of a year old? Will the Lord be pleased with thousands of rams, or with ten thousands of rivers of oil? Shall I give my first born for my transgression, the fruit of my body for the sin of my soul?" The barbarities which have been inflicted by mankind to allay their superstitious fears, seem to have no bounds or limitation. It is horrible to reflect, that the most painful death which the mind can figure, burning alive, has been alike the sacrifice of the moderns for erroneous religious tenets, and of the ancients to gain the favour, or to avert the wrath of their Deities. The *Moloch* of the Phenicians, the *Kronus* of the

Arreoys.

Greeks, the *Kali* of the Hindoos, were all sanguinary Deities. Children sacrificed to the two former, were precipitated into the arms of an idol, heated red-hot in a furnace; and thence, by a particular mechanism, fell into the fire. Hamilcar, on receiving sinister intelligence, attended with alarming circumstances, immediately seized on a boy, and sacrificed him to *Kronus*. On another occasion, the enemy being at the gates of Carthage, two hundred children of the first citizens were offered as a public sacrifice to avert the danger. "Yea, they sacrificed their sons and their daughters unto devils, and shed innocent blood, even the blood of their sons and daughters, whom they sacrificed unto the idols of Canaan, and the land was polluted with blood." But farther, we are told, that the mother herself, who offered her child in sacrifice, never uttered a sigh, lest its efficacy might be impaired; and while this innocent blood was flowing from hundreds of victims, their screams were drowned in the noise of clarions and tabors, provided by the priests for the ceremony. "Tell me," says Plutarch, "were the monsters of old, the Typhons, and the Giants, to expel the Gods, and rule the world in their place, would they exact a duty more horrid than such infernal rites?"

Perhaps, therefore, the murderous practices of the Arreoys in the South Sea Islands, may have originated in some religious principle. At the same time, it appears, that, in the ordinary destruction of infants by the Islanders of the South Pacific Ocean, there is nothing of a sacrificial nature; for, though they do not suppose that their displeasure is thereby incurred, they do not pretend that the practice is acceptable to any of their Divinities. Mr Malthus, we may add, ascribes the origin of the Arreoy institutions to a superabundance of population, and the necessity of adopting some forcible expedients to bring it within the limits of subsistence. Of late years, much exertion has been made by the Missionaries to root out this sanguinary practice, but hitherto without producing any material effect. See Forster's *Voyage*, Vol. II.—Cook's *First and Second Voyage*.—Bligh's *Voyage*.—*Missionary Voyage*.—Hamilton's *Account of the Loss of the Pandora*. (s.)

# ARTS, FINE.

Objects of the Article.

In the *Encyclopædia* there is some account, under the head Arts, of the general theory and history of the *Fine Arts*, including Poetry, Eloquence, Painting, Statuary, and Architecture. The term, in its widest application, would also embrace Music, Dancing, Theatrical Exhibition; and in general, all those arts, in which the powers of imitation or invention are exerted, chiefly with a view to the production of pleasure, by the immediate impression which they make on the mind. The phrase has of late, we think, been restricted to a narrower and more technical signification; namely, to Painting, Sculpture, Engraving, and Architecture, which appeal to the eye as the medium of pleasure; and by way of eminence, to the two first of these arts. In the present article, we shall adopt this limited sense of the term; and shall endeavour to develope the principles upon which the great Masters have proceeded, and also to inquire, in a more particular manner, into the present state and probable advancement of these arts in this Country.

Ruling Principle of the Fine Arts.

The great works of art, at present extant, and which may be regarded as models of perfection in their several kinds, are the Greek statues—the pictures of the celebrated Italian Masters—those of the Dutch and Flemish schools—to which we may add the comic productions of our own countryman, Hogarth. These all stand unrivalled in the history of art; and they owe their pre-eminence and perfection to one and the same principle,—*the immediate imitation of nature*. This principle predominated equally in the classical forms of the antique, and in the grotesque figures of Hogarth; the perfection of art in each arose from the truth and identity of the imitation with the reality; the difference was in the subjects; there was none in the mode of imitation. Yet the advocates for the *ideal system of art* would persuade their disciples, that the difference between Hogarth and the antique does not consist in the different forms of nature which they imitated, but in this, that the one is like, and the other unlike nature. This is an error, the most detrimental, perhaps, of all others, both to the theory and practice of art. As, however, the prejudice is very strong and general, and supported by the highest authority, it will be necessary to go somewhat elaborately into the question, in order to produce an impression on the other side.

What has given rise to the common notion of the *ideal*, as something quite distinct from *actual* nature, is probably the perfection of the Greek statues. Not seeing among ourselves, anything to correspond in beauty and grandeur, either with the features or form of the limbs in these exquisite remains of antiquity, it was an obvious, but a superficial conclusion, that they must have been created from the idea existing in the artist's mind, and could not have been copied from anything existing in nature. The contrary, however, is the fact. The general form, both of the face and figure, which we observe in the old statues, is not an ideal abstraction, is not a fanciful invention of the sculptor, but is as completely local and national (though it happens to be more beautiful), as the figures on a Chinese screen, or a copperplate engraving of a negro chieftain in a book of travels. It will not be denied, that there is a difference of physiognomy as well as of complexion in different races of men. The Greek form appears to have been naturally beautiful, and they had, besides, every advantage of climate, of dress, of exercise, and modes of life to improve it. The artist had also every facility afforded him in the study and knowledge of the human form, and their religious and public institutions gave him every encouragement in the prose-

cution of his art. All these causes contributed to the perfection of these noble productions; but we should be inclined principally to attribute the superior symmetry of form common to the Greek statues, in the first place, to the superior symmetry of the models in nature, and in the second, to the more constant opportunities for studying them. If we allow, also, for the superior genius of the people, we shall not be wrong; but this superiority consisted in their peculiar susceptibility to the impressions of what is beautiful and grand in nature. It may be thought an objection to what has just been said, that the antique figures of animals, &c., are as fine, and proceed on the same principles as their statues of gods or men. But all that follows from this seems to be, that their art had been perfected in the study of the human form, the test and proof of power and skill; and was then transferred easily to the general imitation of all other objects, according to their true characters, proportions, and appearances. As a confirmation of these remarks, the antique portraits of individuals were often superior even to the personifications of their gods. We think that no unprejudiced spectator of real taste can hesitate for a moment in preferring the head of the Antinous, for example, to that of the Apollo. And in general, it may be laid down as a rule, that the most perfect of the antiques are the most simple;—those which affect the least action, or violence of passion;—which repose the most on natural beauty of form, and a certain expression of sweetness and dignity, that is, which remain most nearly in that state in which they could be copied from nature without straining the limbs or features of the individual, or racking the invention of the artist. This tendency of Greek art to repose has indeed been reproached with insipidity by those who had not a true feeling of beauty and sentiment. We, however, prefer these models of habitual grace or internal grandeur to the violent distortions of suffering in the Laocoon, or even to the supercilious air of the Apollo. The Niobe, more than any other antique head, combines truth and beauty with deep passion. But here the passion is fixed, intense, habitual;—it is not a sudden or violent gesticulation, but a settled mould of features; the grief it expresses is such as might almost turn the human countenance itself *into marble!*

In general, then, we would be understood to maintain, that the beauty and grandeur so much admired in the Greek statues were not a voluntary fiction of the brain of the artist, but existed substantially in the forms from which they were copied, and by which the artist was surrounded. A striking authority in support of these observations, which has in some measure been lately discovered, is to be found in the *Elgin marbles*, taken from the Acropolis at Athens, and supposed to be the works of the celebrated Phidias. The process of fastidious refinement and indefinite abstraction is certainly not visible there. The figures have all the ease, the simplicity, and variety, of individual nature. Even the details of the subordinate parts, the loose hanging folds in the skin, the veins under the belly, or on the sides of the horses, more or less swelled as the animal is more or less in action, are given with scrupulous exactness. This is true nature and true art. In a word, these invaluable remains of antiquity are precisely like casts taken from life. The *ideal* is not the preference of that which exists only in the mind, to that which exists in nature; but the preference of that which is fine in nature to that which is less so. There is nothing fine in art but what is taken almost immediately, and, as it were, in the mass, from what is finer in nature. Where there have been the finest models in nature, there have been the finest works of art.

As the Greek statues were copied from Greek forms, so Raphael's expressions were taken from Italian faces; and we have heard it remarked, that the women in the streets at Rome seem to have walked out of his pictures in the Vatican.

Sir Joshua Reynolds constantly refers to Raphael as the highest example in modern times (at least with one exception) of the grand or ideal style; and yet he makes the essence of that style to consist in the embodying an abstract or general idea, formed in the mind of the artist by rejecting the peculiarities of individuals, and retaining only what is common to the species. Nothing can be more inconsistent than the style of Raphael with this definition. In his Cartoons and in his groupes in the Vatican, there is hardly a face or figure which is any thing more than fine individual nature finely disposed and copied. The late Mr Barry, who could not be suspected of a prejudice on this side of the question, speaks thus of them: "In Raphael's pictures (at the Vatican) of the *Dispute of the Sacrament*, and the *School of Athens*, one sees all the heads to be entirely copied from particular characters in nature, nearly proper for the persons and situations which he adapts them to; and he seems to me only to add and take away what may answer his purpose in little parts, features, &c.; conceiving, while he had the head before him, ideal characters and expressions, which he adapts these features and peculiarities of face to. This attention to the particulars which distinguish all the different faces, persons, and characters, the one from the other, gives his pictures quite the verity and unaffected dignity of nature, which stamp the distinguishing differences betwixt one man's face and body and another's."

If any thing is wanting to the conclusiveness of this testimony, it is only to look at the pictures themselves; particularly the *Miracle of the Conversion*, and the *Assembly of Saints*, which are little else than a collection of divine portraits, in natural and expressive attitudes, full of the loftiest thought and feeling, and as varied as they are fine. It is this reliance on the power of nature which has produced those masterpieces by the prince of painters, in which expression is all in all;—where one spirit,—that of truth,—pervades every part, brings down Heaven to Earth, mingles Cardinals and Popes with Angels and Apostles,—and yet blends and harmonizes the whole by the true touches and intense feeling of what is beautiful and grand in nature. It is no wonder that Sir Joshua, when he first saw Raphael's pictures in the Vatican, was at a loss to discover any great excellence in them, if he was looking out for

his theory of the *ideal*,—of neutral character and middle forms.

There is more an appearance of abstract grandeur of form in Michael Angelo. He has followed up, has enforced, and expanded, as it were, a preconceived idea, till he sometimes seems to tread on the verge of caricature. His forms, however, are not *middle*, but *extreme* forms, massy, gigantic, supernatural. They convey the idea of the greatest size and strength in the figure, and in all the parts of the figure. Every muscle is swollen and turgid. This tendency to exaggeration would have been avoided, if Michael Angelo had recurred more constantly to nature, and had proceeded less on a scientific knowledge of the structure of the human body; for science gives only the positive form of the different parts, which the imagination may afterwards magnify, as it pleases, but it is nature alone which combines them with perfect truth and delicacy, in all the varieties of motion and expression. It is fortunate that we can refer, in illustration of our doctrine, to the admirable fragment of the Theseus at Lord Elgin's, which shows the possibility of uniting the grand and natural style in the highest degree. The form of the limbs, as affected by pressure or action, and the general sway of the body, are preserved with the most consummate mastery. We should prefer this statue as a model for forming the style of the student to the Apollo, which strikes us as having something of a theatrical appearance, or to the Hercules, in which there is an ostentatious and over-laboured display of anatomy. This last figure is so overloaded with sinews, that it has been suggested as a doubt, whether, if life could be put into it, it would be able to move. Grandeur of conception, truth of nature, and purity of taste, seem to have been at their height when the masterpieces which adorned the temple of Minerva at Athens, of which we have only these imperfect fragments, were produced. Compared with these, the later Greek statues display a more elaborate workmanship, more of the artifices of style. The several parts are more uniformly balanced, made more to tally like modern periods: each muscle is more equally brought out, and more highly finished as a part, but not with the same subordination of each part to the whole. If some of these wonderful productions have a fault, it is the want of that entire and naked simplicity which pervades the whole of the *Elgin marbles*.

Works of the Grecian and Italian Artists.

Having spoken here of the Greek statues, and of the works of Raphael and Michael Angelo, as far as relates to the imitation of nature, we shall attempt to point out, to the best of our ability, and as concisely as possible, what we conceive to be their general and characteristic excellences. The ancients excelled in beauty of form; Michael Angelo in grandeur of conception; Raphael in expression. In Raphael's faces, particularly his women, the expression is very superior to the form; in the ancient statues, the form is the principal thing. The interest which the latter excite, is in a manner external; it depends on a certain grace and lightness of appearance, joined with exquisite symmetry and refined susceptibility to voluptuous emotions; but there is in general a want of pathos. In their looks, we do not read the workings of the heart; by their beauty they seem raised above the sufferings of humanity, by their beauty they are deified. The pathos which they exhibit is rather that of present and physical distress, than of deep internal sentiment. What has been remarked of Leonardo da Vinci, is also true of Raphael, that there is an angelic sweetness and tenderness in his faces, in which human frailty and passion are purified by the sanctity of religion. The ancient statues are finer objects for the eye to contemplate; they represent a more perfect race of physical beings, but we have little sympathy with them. In Raphael, all our natural sensibilities are heightened and refined by the sentiments of faith and hope, pointing mysteriously to the interests of another world. The same intensity of passion appears also to distinguish Raphael from Michael Angelo. Michael Angelo's forms are grander, but they are not so informed with expression. Raphael's, however ordinary in themselves, are full of expression, "even to o'erflowing;" every nerve and muscle is impregnated with feeling,—bursting with meaning. In Michael Angelo, on the contrary, the powers of body and mind appear superior to any events that can happen to them; the capacity of thought and feeling is never full, never strained or tasked to the extremity of what it will bear. All is in a lofty repose and solitary grandeur, which no human interests can shake or disturb. It has been said, that Michael Angelo painted *man*, and Raphael *men*; that the one was an epic, the other a dramatic painter. But the distinction we have stated is, perhaps, truer and more intelligible, *viz.* that the one gave greater dignity of form, and the other greater force and refinement of expression. Michael Angelo, in fact, borrowed his style from sculpture. He represented, in general, only single figures (with subordinate accompaniments), and had not to express the conflicting actions and passions of a multitude of persons. It is therefore a mere truism to say, that his compositions are not dramatic. He is much more picturesque than Raphael. The whole figure of his *Jeremiah* droops and hangs down like a majestic tree surcharged with showers. His drawing of the human form has the characteristic freedom and boldness of Titian's landscapes.

After Michael Angelo and Raphael, there is no doubt that Leonardo da Vinci, and Correggio, are the two painters, in modern times, who have carried historical expression to the highest ideal perfection; and yet it is equally certain that their heads are carefully copied from faces and expressions in nature. Leonardo excelled principally in his women and children. We find, in his female heads, a peculiar charm of expression; a character of natural sweetness and tender playfulness, mixed up with the pride of conscious intellect, and the graceful reserve of personal dignity. He blends purity with voluptuousness; and the expression of his women is equally characteristic of "the mistress or the saint." His pictures are worked up to the height of the idea he had conceived, with an elaborate felicity; but this idea was evidently first suggested, and afterwards religiously compared with nature. This was his excellence. His fault is, that his style of execution is

too mathematical; that is, his pencil does not follow the graceful variety of the details of objects, but substitutes certain refined gradations, both of form and colour, producing equal changes in equal distances, with a mechanical uniformity. Leonardo was a man of profound learning as well as genius, and perhaps transferred too much of the formality of science to his favourite art.

The masterpieces of Correggio have the same identity with nature, the same stamp of truth. He has indeed given to his pictures the utmost softness and refinement of outline and expression; but this idea, at which he constantly aimed, is filled up with all the details and varieties which such heads would have in nature. So far from any thing like a naked abstract idea, or middle form, the *individuality* of his faces has something peculiar in it, even approaching the grotesque. He has endeavoured to impress habitually on the countenance, those undulating outlines which rapture or tenderness leave there, and has chosen for this purpose those forms and proportions which most obviously assisted his design.

As to the colouring of Correggio, it is nature itself. Not only the general tone is perfectly true, but every speck and particle is varied in colour, in relief, in texture, with a care, a felicity, and an effect, which is almost magical. His light and shade are equally admirable. No one else, perhaps, ever gave the same harmony and roundness to his compositions. So true are his shadows,—equally free from coldness, opacity, or false glare;—so clear, so broken, so airy, and yet so deep, that if you hold your hand so as to cast a shadow on any part of the flesh which is in the light, this part, so shaded, will present exactly the same appearance which the painter has given to the shadowed part of the picture. Correggio, indeed, possessed a greater variety of excellences in the different departments of his art, than any other painter; and yet it is remarkable, that the impression which his pictures leave upon the mind of the common spectator, is monotonous and comparatively feeble. His style is in some degree mannered and confined. For instance, he is without the force, passion, and grandeur of Raphael, who, however, possessed his softness of expression, but of expression only; and in colour, in light and shade, and other qualities, was quite inferior to Correggio. We may, perhaps, solve this apparent contradiction by saying, that he applied the power of his mind to a greater variety of objects than others; but that this power was still of the same character; consisting in a certain exquisite sense of the harmonious, the soft and graceful in form, colour, and sentiment, but with a deficiency of strength, and a tendency to effeminacy in all these.

After the names of Raphael and Correggio, we shall mention that of Guido, whose female faces are exceedingly beautiful and ideal, but altogether commonplace and vapid, compared with those of Raphael or Correggio; and they are so, for no other reason but that the general idea they convey is not enriched and strengthened by an intense contemplation of nature. For the same reason, we can conceive nothing more unlike the antique than the figures of Nicholas Poussin, except as to the preservation of the costume; and it is perhaps chiefly owing to the habit of studying his art at second-hand, or by means of scientific rules, that the great merits of that able painter, whose understanding and genius are unquestionable, are confined to his choice of subjects for his pictures, and his manner of telling the story. His landscapes, which he probably took from nature, are superior as paintings to his historical pieces. The faces of Poussin want natural expression, as his figures want grace; but the back-grounds of his historical compositions can scarcely be surpassed. In his plague of Athens, the very buildings seem stiff with horror. His giants, seated on the top of their fabled mountains, and playing on their Pan's pipes, are as familiar and natural as if they were the ordinary inhabitants of the scene. The finest of his landscapes is his picture of the Deluge. The sun is just seen wan and drooping in his course. The sky is bowed down with a weight of waters, and Heaven and earth seem mingling together.

Titian is at the head of the Venetian school. He is the first of all colourists. In delicacy and purity Correggio is equal to him, but his colouring has not the same warmth and gusto in it. Titian's flesh-colour partakes of the glowing nature of the climate, and of the luxuriousness of the manners of his country. He represents objects not through a merely lucid medium, but as if tinged with a golden light. Yet it is wonderful in how low a tone of local colouring his pictures are painted,—how rigidly his means are husbanded. His most gorgeous effects are produced, not less by keeping down, than by heightening his colours; the fineness of his gradations adds to their variety and force; and, with him, truth is the same thing as splendour. Every thing is done by the severity of his eye, by the patience of his touch. He is enabled to keep pace with nature, by never hurrying on before her; and as he forms the broadest masses out of innumerable varying parts and minute strokes of the pencil, so he unites and harmonises the strongest contrasts by the most imperceptible transitions. Every distinction is relieved and broken by some other intermediate distinction, like half notes in music; and yet all this accumulation of endless variety is so managed, as only to produce the majestic simplicity of nature; so that to a common eye there is nothing extraordinary in his pictures, any more than in nature itself. It is, we believe, owing to what has been here stated, that Titian is, of all painters, at once the easiest and the most difficult to copy. He is the most difficult to copy perfectly, for the artifice of his colouring and execution is hid in its apparent simplicity; and yet the knowledge of nature, and the arrangement of the forms and masses in his pictures, is so masterly, that any copy made from them, even the rudest outline or sketch, can hardly fail to have a look of high art. Because he was the greatest colourist in the world, this, which was his most prominent, has, for shortness, been considered as his only excellence; and he has been said to have been ignorant of drawing. What he was, generally speaking, deficient in, was invention or composition, though even this appears to have been more from habit than want of power; but his drawing of actual forms, where they were not to be put into momentary action, or adapted to a particular expression, was as

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fine as possible. His drawing of the forms of inanimate objects is unrivalled. His trees have a marked character and physiognomy of their own, and exhibit an appearance of strength or flexibility, solidity or lightness, as if they were endued with conscious power and purposes. Character was another excellence which Titian possessed in the highest degree. It is scarcely speaking too highly of his portraits to say, that they have as much expression, that is, convey as fine an idea of intellect and feeling, as the historical heads of Raphael. The chief difference appears to be, that the expression in Raphael is more imaginary and contemplative, and in Titian more personal and constitutional. The heads of the one seem thinking more of some event or subject, those of the other to be thinking more of themselves. In the portraits of Titian, as might be expected, the Italian character always predominates; there is a look of piercing sagacity, of commanding intellect, of acute sensibility, which it would be in vain to seek for in any other portraits. The daring spirit and irritable passions of the age and country, are distinctly stamped upon their countenances, and can be as little mistaken as the costume which they wear. The portraits of Raphael, though full of profound thought and feeling, have more of common humanity about them. Titian's portraits are the most historical that ever were painted; and they are so, for this reason, that they have most consistency of form and expression. His portraits of Hippolito de Medici, and of a young Neapolitan nobleman, lately in the gallery of the Louvre, are a striking contrast in this respect. All the lines of the face in the one, the eye-brows, the nose, the corners of the mouth, the contour of the face, present the same sharp angles, the same acute, edgy, contracted, violent expression. The other portrait has the finest expansion of feature and outline, and conveys the most exquisite idea possible, of mild, thoughtful sentiment. The consistency of the expression constitutes as great a charm in Titian's portraits, as the harmony of the colouring. The similarity sometimes objected to his heads, is partly national, and partly arises from the class of persons whom he painted. He painted only Italians; and in his time it rarely happened, that any but persons of the highest rank, Senators, or Cardinals, sat for their pictures. The similarity of costume of the dress, the beard, &c. also adds to the similarity of their appearance. It adds, at the same time, to their picturesque effect; and the alteration in this respect, is one circumstance among others that has been injurious, not to say fatal, to modern art. This observation is not confined to portrait; for the hired dresses with which our historical painters clothe their figures, sit no more easily on the imagination of the artist, than they do gracefully on the lay-figures over which they are thrown.

Giorgioni, Paul Veronese, Tintoret, and the Bassans, are the remaining great names of the Venetian school. The excellence of all of them consisted in the bold, masterly, and striking imitation of nature. Their want of *ideal form*, and elevated character, is, indeed, a constant subject of reproach against them. Giorgioni takes the first place among them; for he was in some measure the master of Titian, whereas the others were only his disciples. The Carraccis, Domenichino, and the rest of the Bolognese school, formed themselves on a principle of combining the excellences of the Roman and Venetian painters, in which they for a while succeeded to a considerable degree; but they degenerated and dwindled away into absolute insignificance, in proportion as they departed from nature, or the great masters who had copied her, to mould their works on academic rules, and the phantoms of abstract perfection.

Flemish and Dutch Painters.

Rubens is the Prince of the Flemish painters. Of all the great painters, he is perhaps the most artificial,—the one who painted most from his own imagination,—and, what was almost the inevitable consequence, the most of a mannerist. He had neither the Greek forms to study from, nor the Roman expression, nor the high character, picturesque costume, and sun-burnt hues which the Venetian painters had immediately before them. He took, however, what circumstances presented to him,—a fresher and more blooming tone of complexion, arising from moister air, and a colder climate. To this he added the congenial splendour of reflected lights and shadows cast from rich drapery; and he made what amends he could for the want of expression, by the richness of his compositions, and the fantastic variety of his allegorical groups. Both his colouring and his drawing were, however, ideal exaggerations. But both had particular qualities of the highest value. He has given to his flesh greater transparency and freshness, than any other painter; and this excellence he had from nature. One of the finest instances will be found in his *Peasant Family going to Market*, in which the figures have all the bloom of health upon their countenances; and the very air of the surrounding landscape strikes sharp and wholesome on the sense. Rubens had another excellence; he has given all that relates to the expression of motion in his allegorical figures, in his children, his animals, even in his trees, to a degree which no one else has equalled, or indeed approached. His drawing is often deficient in proportion, in knowledge, and in elegance, but it is always picturesque. The drawing of N. Poussin, on the contrary, which has been much cried up, is merely learned and anatomical: he has a knowledge of the structure and measurements of the human body, but very little feeling of the grand, or beautiful, or striking, in form. All Rubens's forms have ease, freedom, and excessive elasticity. In the grotesque style of history,—as in the groups of satyrs, nymphs, bacchanals, and animals, where striking contrasts of form are combined with every kind of rapid and irregular movement, he has not a rival. Witness his Silenus at Blenheim, where the lines seem drunk and staggering; and his procession of Cupids riding on animals at Whitehall, with that adventurous leader of the infantine crew, who, with a spear, is urging a lion, on which he is mounted, over the edge of the world; for beyond we only see a precipice of clouds and sky. Rubens's power of expressing motion perhaps arose from the facility of his pencil, and his habitually trusting a good deal to memory and imagination in his compositions; for this quality can be given in no other way. His portraits are the least

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valuable productions of his pencil. His landscapes are often delightful, and appear like the work of fairy hands.

It remains to speak of Vandyke and Rembrandt, the one the disciple of Rubens, the other the entire founder of his own school. It is not possible for two painters to be more opposite. The characteristic merits of the former are very happily summed up in a single line of a poetical critic, where he speaks of

"The soft precision of the clear Vandyke."

The general object of this analysis of the works of the great masters, has been to show, that their pre-eminence has constantly depended, not on the creation of a fantastic, abstract excellence, existing nowhere but in their own minds, but in their selecting and embodying some one view of nature, which came immediately under their habitual observation, and which their particular genius led them to study and imitate with success. This is certainly the case with Vandyke. His portraits, mostly of English women, in the collection in the Louvre, have a cool refreshing air about them, a look of simplicity and modesty even in the very tone, which forms a fine contrast to the voluptuous glow and mellow golden lustre of Titian's Italian women. There is a quality of flesh-colour in Vandyke which is to be found in no other painter, and which exactly conveys the idea of the soft, smooth, sliding, continuous, delicately varied surface of the skin. The objects in his pictures have the least possible difference of light and shade, and are presented to the eye without passing through any indirect medium. It is this extreme purity and silvery clearness of tone, together with the facility and precision of his particular forms, and a certain air of fashionable elegance, characteristic of the age in which he flourished, that places Vandyke in the first rank of portrait painters.

If ever there was a man of genius in the art, it was Rembrandt. He might be said to have created a medium of his own, through which he saw all objects. He was the grossest and the least vulgar, that is to say, the least common-place in his grossness, of all men. He was the most downright, the least fastidious of the imitators of nature. He took any object, he cared not what, how mean soever in form, colour, and expression, and from the light and shade which he threw upon it, it came out gorgeous from his hands. As Vandyke made use of the smallest contrasts of light and shade, and painted as if in the open air, Rembrandt used the most violent and abrupt contrasts in this respect, and painted his objects as if in a dungeon. His pictures may be said to be "bright with excessive darkness." His vision had acquired a lynx-eyed sharpness from the artificial obscurity to which he had accustomed himself. "Mystery and silence hung upon his pencil." Yet he could pass rapidly from one extreme to another, and dip his colours with equal success in the gloom of night, or in the blaze of the noon-day sun. In surrounding different objects with a medium of imagination, solemn or dazzling, he was a true poet; in all the rest, he was a mere painter, but a painter of no common stamp. The powers of his hand were equal to those of his eye; and indeed he could not have attempted the subjects he did, without an execution as masterly as his knowledge was profound. His colours are sometimes dropped in lumps on the canvass; at other times they are laid on as smooth as glass; and he not unfrequently painted with the handle of his brush. He had an eye for all objects as far as he had seen them. His history and landscapes are equally fine in their way. His landscapes we could look at for ever, though there is nothing in them. But "they are of the earth, earthy." It seems as if he had dug them out of nature. Every thing is so true, so real, so full of all the feelings and associations which the eye can suggest to the other senses, that we immediately take as strong an affection to them, as if they were our home—the very place where we were brought up. No length of time could add to the intensity of the impression they convey. Rembrandt is the least classical and the most romantic of all painters. His Jacob's Ladder is more like a dream than any other picture that ever was painted. The figure of Jacob himself is thrown in one corner of the picture like a bundle of clothes, while the angels hover above the darkness, in the shape of airy wings.

It would be needless to prove that the generality of the Dutch painters copied from actual objects. They have become almost a bye-word for carrying this principle into its abuse, by copying every thing they saw, and having no choice or preference of one thing to another, unless that they preferred that which was most obvious and common. We forgive them. They perhaps did better in faithfully and skilfully imitating what they had seen, than in imagining what they had not seen. Their pictures at least show, that there is nothing in nature, however mean or trivial, that has not its beauty and some interest belonging to it, if truly represented. We prefer Vangoyen's views on the borders of a canal, the yellow-tufted bank, and passing sail, or Ruysdael's woods and sparkling water falls, to the most classical or epic compositions which they could have invented out of nothing; and we think that Teniers's boors, old women, and children, are very superior to the little carved ivory Venuses in the pictures of Vanderneer; just as we think Hogarth's *Marriage à la Mode* is better than his Sigismunda, or as Mr Wilkie's Card-Players is better than his Alfred. We should not assuredly prefer a *Dutch Fair* by Teniers to a *Cartoon* by Raphael; but we suspect we should prefer a Dutch Fair by Teniers to a Cartoon by the same master; or we should prefer truth and nature in the simplest dress, to affectation and inanity in the most pompous disguise. Whatever is genuine in art, must proceed from the impulse of nature and individual genius.

French and Spanish Painters.

In the French school there are but two names of high and established reputation, N. Poussin and Claude Lorraine. Of the former we have already spoken: of the latter we shall give our opinion when we come to speak of our own Wilson. We ought not to pass over the names of Murillo and Velasquez, those admirable Spanish painters. It is difficult to characterize their peculiar excellences as distinct from those of the Italian and Dutch schools. They may be said to hold a middle rank between

Fine Arts. the painters of mind and body. They express not so much thought and sentiment, nor yet the mere exterior, as the life and spirit of the man. Murillo is probably at the head of that class of painters who have treated subjects of common life. After making the colours on the canvass feel and think, the next best thing is to make them breathe and live. But there is in Murillo's pictures of this kind a look of real life, a cordial flow of native animal spirits, which we find nowhere else. We might here refer particularly to his picture of the *Two Spanish Beggar-boys* in the collection at Dulwich College, which cannot easily be forgotten by those who have ever seen it.

Progress of Art in Britain. We come now to speak of the progress of art in our own Country,—of its present state,—and the means proposed for advancing it to still higher perfection.

Hogarth. We shall speak first of Hogarth, both as he is the first name in the order of time that we have to boast of, and as he is the greatest comic painter of any age or country. His pictures are not imitations of still life, or mere transcripts of incidental scenes or customs; but powerful moral satires, exposing vice and folly in their most ludicrous points of view, and with a profound insight into the weak sides of character and manners, in all their tendencies, combinations, and contrasts. There is not a single picture of his, containing a representation of merely natural or domestic scenery. His object is not so much "to hold the mirror up to nature," as "to show vice her own feature, scorn her own image." Folly is there seen at the height—the moon is at the full—it is the very error of the time. There is a perpetual collision of eccentricities, a tilt and tournament of absurdities, pampered into all sorts of affectation, airy, extravagant, and ostentatious! Yet he is as little a caricaturist as he is a painter of still life. Criticism has not done him justice, though public opinion has. His works have received a sanction which it would be vain to dispute, in the universal delight and admiration with which they have been regarded, from their first appearance, to the present moment. If the quantity of amusement, or of matter for reflection which they have afforded, is that by which we are to judge of precedence among the intellectual benefactors of mankind, there are perhaps few persons who can put in a stronger claim to our gratitude than Hogarth. The wonderful knowledge which he possessed of human life and manners, is only to be surpassed (if it can be) by the powers of invention with which he has arranged his materials, and by the mastery of execution with which he has embodied and made tangible the very thoughts and passing movements of the mind. Some persons object to the style of Hogarth's pictures, or the class to which they belong. First, Hogarth belongs to no class, or, if he belongs to any, it is to the same class as Fielding, Smollett, Vanbrugh, and Moliere. Besides, the merit of his pictures does not depend on the nature of his subjects, but on the knowledge displayed of them, on the number of ideas, on the fund of observation and amusement contained in them. Make what deductions you please for the vulgarity of the subjects—yet in the research, the profundity, the absolute truth and precision of the delineation of character,—in the invention of incident, in wit and humour, in life and motion, in everlasting variety and originality,—they never have, and probably never will be surpassed. They stimulate the faculties, as well as amuse them. "Other pictures we see, Hogarth's we read!" *

There is one error which has been frequently entertained on this subject, and which we wish to correct, namely, that Hogarth's genius was confined to the imitation of the coarse humours and broad farce of the lowest life. But he excelled quite as much in exhibiting the vices, the folly, and frivolity of the fashionable manners of his time. His fine ladies do not yield the palm of ridicule to his waiting-maids, and his lords and his porters are on a very respectable footing of equality. He is quite at home, either in St Giles's or St James's. There is no want, for example, in his *Marriage à la Mode*, or his *Taste in High Life*, of affectation verging into idiotcy, or of languid sensibility that might

"Die of a rose in aromatic pain."

Many of Hogarth's characters would form admirable illustrations of Pope's Satires, who was contemporary with him. In short, Hogarth was a painter of real, not of low life. He was, as we have said, a satirist, and consequently his pencil did not dwell on the grand and beautiful, but it glanced with equal success at the absurdities and peculiarities of high or low life, "of the great vulgar and the small."

To this it must be added, that he was as great a master of passion as of humour. He succeeded in low tragedy, as much as in low or genteel comedy, and had an absolute power in moving the affections and rending the hearts of the spectators, by depicting the effects of the most dreadful calamities of human life, on common minds and common countenances. Of this, the *Rake's Progress*, particularly the Bedlam scene, and many others, are unanswerable proofs. Hogarth's merits, as a mere artist, are not confined to his prints. In general, indeed, this is the case. But when he chose to take pains, he could add the delicacies of execution and colouring in the highest degree to those of character and composition; as is evident in the series of pictures, all equally well painted, of *the Marriage à la Mode*, exhibited lately at the British Institution.

Wilson. We shall next speak of Wilson, whose pictures may be divided into three classes:—his Italian landscapes, or imitations of the manner of Claude,—his copies of English scenery,—and his historical compositions. The first of these are, in our opinion, by much the best; and we appeal, in support of this opinion, to the *Apollo and the Seasons*, and to the *Phaeton*. The figures are of course out of the question (these being as uncouth and slovenly as Claude's are insipid and finical); but the landscape,

* See an admirable Essay on the genius of Hogarth, by Charles Lamb, in a periodical work, called *The Reflector*.

in both pictures, is delightful. In looking at them, we breathe the air which the scene inspires, and feel the genius of the place present to us. In the first, there is the cool freshness of a misty spring morning; the sky, the water, the dim horizon, all convey the same feeling. The fine grey tone, and varying outline of the hills; the graceful form of the retiring lake, broken still more by the hazy shadows of the objects that repose on its bosom; the light trees that expand their branches in the air; and the dark stone figure and mouldering temple, that contrast strongly with the broad clear light of the rising day,—give a charm, a truth, a force and harmony to this composition, which produce the greater pleasure the longer it is dwelt on. The distribution of light and shade resembles the effect of light on a globe. The *Phaeton* has the dazzling fervid appearance of an autumnal evening; the golden radiance streams in solid masses from behind the flickering clouds; every object is baked in the sun;—the brown fore-ground, the thick foliage of the trees, the streams, shrunk and stealing along behind the dark high banks,—combine to produce that richness, and characteristic unity of effect, which is to be found only in nature, or in art derived from the study and imitation of nature. These two pictures, as they have the greatest general effect, are also more carefully finished than any other pictures we have seen of his.

In general, Wilson's views of *English scenery* want almost every thing that ought to recommend them. The subjects he has chosen are not well fitted for the landscape-painter, and there is nothing in the execution to redeem them. Ill-shaped mountains, or great heaps of earth, trees that grow against them without character or elegance, motionless waterfalls, a want of relief, of transparency and distance, without the imposing grandeur of real magnitude (which it is scarcely within the province of art to give),—are the chief features and defects of this class of his pictures. In more confined scenes, the effect must depend almost entirely on the difference in the execution and the details; for the difference of colour alone is not sufficient to give relief to objects placed at a small distance from the eye. But, in Wilson, there are commonly no details,—all is loose and general; and this very circumstance, which might assist him in giving the massy contrasts of light and shade, deprived his pencil of all force and precision within a limited space. In general, air is necessary to the landscape-painter; and, for this reason, the lakes of Cumberland and Westmoreland afford few subjects for landscape-painting. However stupendous the scenery of that country is, and however powerful and lasting the impression which it must always make on the imagination, yet the effect is not produced merely through the medium of the eye, but arises chiefly from collateral and associated feelings. There is the knowledge of the physical magnitude of the objects in the midst of which we are placed,—the slow, improgressive motion, which we make in traversing them;—there is the abrupt precipice, the torrent's roar, the boundless expanse of the prospect from the highest mountains,—the difficulty of their ascent, their loneliness and silence; in short, there is a constant sense and superstitious awe of the collective power of matter, of the gigantic and eternal forms of nature, on which, from the beginning of time, the hand of man has made no impression, and which, by the lofty reflections they excite in us, give a sort of intellectual sublimity even to our sense of physical weakness. But there is little in all these circumstances that can be translated into the *picturesque*, which makes its appeal immediately to the eye.

Wilson's historical landscapes, his *Niobe, Celadon and Amelia*, &c. do not, in our estimation, display either true taste or fine imagination, but are affected and violent exaggerations of clumsy common nature. They are made up mechanically of the same stock of materials,—an over-hanging rock, bare shattered trees, black rolling clouds, and forked lightning. The figures, in the most celebrated of these, are not like the children of Niobe, punished by the Gods, but like a group of rustics, crouching from a hail-storm. We agree with Sir Joshua Reynolds, that Wilson's mind was not, like N. Poussin's, sufficiently imbued with the knowledge of antiquity to transport the imagination three thousand years back, to give natural objects a sympathy with preternatural events, and to inform rocks, and trees, and mountains, with the presence of a God. To sum up his general character, we may observe, that, besides his excellence in aërial perspective, Wilson had great truth, harmony, and depth of local colouring. He had a fine feeling of the proportions and conduct of light and shade, and also an eye for graceful form, as far as regards the bold and varying outlines of indefinite objects; as may be seen in his foregrounds, &c. where the artist is not tied down to an imitation of characteristic and articulate forms. In his figures, trees, cattle, and in everything having a determinate and regular form, his pencil was not only deficient in accuracy of outline, but even in perspective and actual relief. His trees, in particular, frequently seem pasted on the canvass, like botanical specimens. In fine, we cannot subscribe to the opinion of those who assert, that Wilson was superior to Claude as a man of genius; nor can we discern any other grounds for this opinion, than what would lead to the general conclusion,—that the more slovenly the performance the finer the picture, and that that which is imperfect is superior to that which is perfect. It might be said, on the same principle, that the coarsest sign-painting is better than the reflection of a landscape in a mirror; and the objection that is sometimes made to the mere imitation of nature, cannot be made to the landscapes of Claude, for in them the Graces themselves have, with their own hands, assisted in selecting and disposing every object. Is the general effect in *his* pictures injured by the details? Is the truth inconsistent with the beauty of the imitation? Does the perpetual profusion of objects and scenery, all perfect in themselves, interfere with the simple grandeur and comprehensive magnificence of the whole? Does the precision with which a plant is marked in the foreground, take away from the air-drawn distinctions of the blue glimmering horizon? Is there any want of that endless airy space, where the eye wanders at liberty under the open sky, explores distant objects, and returns back as from a de-

lightful journey? There is no comparison between Claude and Wilson. Sir Joshua Reynolds used to say, that there would be another Raphael before there would be another Claude. His landscapes have all that is exquisite and refined in art and nature. Everything is moulded into grace and harmony; and, at the touch of his pencil, shepherds with their flocks, temples and groves, and winding glades, and scattered hamlets, rise up in never-ending succession, under the azure sky and the resplendent sun, while " universal Pan,

> "Knit with the Graces, and the hours in dance,
> Leads on the eternal spring."——

Michael Angelo has left, in one of his sonnets, a fine apostrophe to the earliest poet of Italy:

> " Fain would I, to be what our Dante was,
> Forego the happiest fortunes of mankind."

What landscape-painter does not feel this of Claude?*

Gainsborough.

We have heard an anecdote connected with the reputation of Gainsborough's pictures, which rests on pretty good authority. Sir Joshua Reynolds, at one of the Academy dinners, speaking of Gainsborough, said to a friend,—" He is undoubtedly the best English landscape-painter." " No," said Wilson, who overheard the conversation, " he is not the best landscape-painter, but he is the best portrait painter in England." They were both wrong; but the story is creditable to the versatility of Gainsborough's talents.

Those of his portraits which we have seen are not in the first rank. They are in a good measure imitations of Vandyke; and have more an air of gentility than of nature. His landscapes are of two classes or periods; his early and his later pictures. The former are minute imitations of nature, or of painters who imitated nature, such as Ruysdael, &c. some of which have great truth and clearness. His later pictures are flimsy caricatures of Rubens, who himself carried inattention to the details to the utmost limit that it would bear. Many of Gainsborough's latter landscapes may be compared to bad water-colour drawings, washed in by mechanical movements of the hand, without any communication with the eye. The truth seems to be, that Gainsborough found there was something wanting in his *early manner*, that is, something beyond the literal imitation of the details of natural objects; and he appears to have concluded rather hastily, that the way to arrive at that *something more*, was to discard truth and nature altogether. His fame rests principally, at present, on his fancy-pieces, cottage-children, shepherd-boys, &c. These have often great truth, great sweetness, and the subjects are often chosen with great felicity. We too often find, however, even in his happiest efforts, a consciousness in the turn of the limbs, and a pensive languor in the expression, which is not taken from nature. We think the gloss of art is never so ill bestowed as on such subjects, the essence of which is simplicity. It is perhaps the general fault of Gainsborough, that he presents us with an ideal common life, of which we have had a surfeit in poetry and romance. His subjects are softened, and sentimentalised too much; it is not simple unaffected nature that we see, but nature sitting for her picture. Our artist, we suspect, led the way to that masquerade style, which piques itself on giving the air of an Adonis to the driver of a hay-cart, and models the features of a milk-maid on the principles of the antique. His *Woodman's Head* is admirable. Nor can too much praise be given to his *Shepherd Boy in a Storm*; in which the unconscious simplicity of the boy's expression, looking up with his hands folded and with timid wonder,—the noisy chattering of a magpie perched above,—and the rustling of the coming storm in the branches of the trees, produce a most delightful and romantic impression on the mind.

Gainsborough was to be considered, perhaps, rather as a man of delicate taste, and of an elegant and feeling mind, than as a man of genius; as a lover of the art, rather than an artist. He devoted himself to it, with a view to amuse and soothe his mind, with the ease of a gentleman, not with the severity of a professional student. He wished to make his pictures, like himself, amiable; but a too constant desire to please almost unavoidably leads to affectation and effeminacy. He wanted that vigour of intellect, which perceives the beauty of truth; and thought that painting was to be gained, like other mistresses, by flattery and smiles. It was an error which we are disposed to forgive in one, around whose memory, both as an artist and a man, many fond recollections, many vain regrets, must always linger. †

Sir Joshua Reynolds.

The authority of Sir Joshua Reynolds, both from his example and instructions, has had, and still continues to have, a considerable influence on the state of art in this country. That influence has been on the whole unquestionably beneficial in itself, as well as highly creditable to the rare talents and elegant mind of Sir Joshua; for it has raised the art of painting from the lowest state of degradation,—of dry, meagre, lifeless inanity, to something at least respectable, and bearing an affinity to the rough strength and bold spirit of the national character. Whether the same implicit deference to his authority, which has helped to advance the art thus far, may not, among other causes, limit and retard its future progress? Whether there are not certain ori-

* This painter's book of studies from nature, commonly called *Liber Veritatis*, disproves the truth of the general opinion that his landscapes are mere artificial compositions, for the finished pictures are nearly facsimiles of the original sketches.

† The idea of the necessity of improving upon nature, and giving what was called a *flattering likeness*, was universal in this country fifty years ago; so that Gainsborough is not to be so much blamed for tampering with his subjects.

ginal errors, both in his principles and practice, which, the farther they are proceeded in, the farther they will lead us from the truth? Whether there is not a systematic bias from the right line by which alone we can arrive at the goal of the highest perfection?—are questions well worth considering.

We shall begin with Sir Joshua's merits as an artist. There is one error which we wish to correct at setting out, because we think it important. There is not a greater or more unaccountable mistake than the supposition that Sir Joshua Reynolds owed his success or excellence in his profession, to his having been the first who introduced into this country more general principles of the art, and who raised portrait to the dignity of history from the low drudgery of copying the peculiarities, meannesses, and details of individual nature, which was all that had been attempted by his immediate predecessors. This is so far from being true, that the very reverse is the fact. If Sir Joshua did not give these details and peculiarities so much as might be wished, those who went before him did not give them at all. Those pretended general principles of the art, which, it is said, "alone give value and dignity to it," had been pushed to their extremest absurdity before his time; and it was in getting rid of the mechanical systematic monotony and *middle forms*, by the help of which Lely, Kneller, Hudson, the French painters, and others, carried on their manufactories of history and face-painting, and in returning (as far as he did return) to the truth and force of individual nature, that the secret both of his fame and fortune lay. The pedantic, servile race of artists, whom Reynolds superseded, had carried the abstract principle of improving on nature to such a degree of refinement, that they left it out altogether; and confounded all the varieties and irregularities of form, feature, character, expression or attitude, in the same artificial mould of fancied grace and fashionable insipidity. The portraits of Kneller, for example, seem all to have been turned in a machine; the eye-brows are arched as if by a compass; the mouth curled, and the chin dimpled, the head turned on one side, and the hands placed in the same affected position. The portraits of this mannerist, therefore, are as like one another as the dresses which were then in fashion; and have the same "dignity and value" as the full-bottomed wigs which graced their originals. The superiority of Reynolds consisted in his being varied and natural, instead of being artificial and uniform. The spirit, grace, or dignity which he added to his portraits, he borrowed from nature, and not from the ambiguous quackery of rules. His feeling of truth and nature was too strong to permit him to adopt the unmeaning style of Kneller and Hudson; but his logical acuteness was not such as to enable him to detect the verbal fallacies and speculative absurdities which he had learned from Richardson and Coypel; and, from some defects in his own practice, he was led to confound negligence with grandeur. But of this hereafter.

Sir Joshua Reynolds owed his vast superiority over his contemporaries to incessant practice, and habitual attention to nature, to quick organic sensibility, to considerable power of observation, and still greater taste in perceiving and availing himself of those excellences of others, which lay within his own walk of art. We can by no means look upon Sir Joshua as having a claim to the first rank of genius. He would hardly have been a great painter, if other greater painters had not lived before him. He would not have given a first impulse to the art, nor did he advance any part of it beyond the point where he found it. He did not present any new view of nature, nor is he to be placed in the same class with those who did. Even in colour, his pallet was spread for him by the old Masters, and his eye imbibed its full perception of depth and harmony of tone, from the Dutch and Venetian schools, rather than from nature. His early pictures are poor and flimsy. He indeed learned to see the finer qualities of nature through the works of art, which he, perhaps, might never have discovered in nature itself. He became rich by the accumulation of borrowed wealth, and his genius was the offspring of taste. He combined and applied the materials of others to his own purpose, with admirable success; he was an industrious compiler, or skilful translator, not an original inventor in art. The art would remain, in all its essential elements, just where it is, if Sir Joshua had never lived. He has supplied the industry of future plagiarists with no new materials. But it has been well observed, that the value of every work of art, as well as the genius of the artist, depends, not more on the degree of excellence, than on the degree of originality displayed in it. Sir Joshua, however, was perhaps the most original imitator that ever appeared in the world: and the reason of this, in a great measure, was, that he was compelled to combine what he saw in art, with what he saw in nature, which was constantly before him. The portrait-painter is, in this respect, much less liable than the historical painter, to deviate into the extremes of manner and affectation; for he cannot discard nature altogether, under the excuse that *she only puts him out*. He must meet her, face to face; and if he is not incorrigible, he will see something there that cannot fail to be of service to him. Another circumstance which must have been favourable to Sir Joshua was, that though not the originator *in point of time*, he was the first Englishman who transplanted the higher excellences of his profession into his own country, and had the merit, if not of an inventor, of a reformer of the art. His mode of painting had the graces of novelty in the age and country in which he lived; and he had, therefore, all the stimulus to exertion, which arose from the enthusiastic applause of his contemporaries, and from a desire to expand and refine the taste of the public.

To an eye for colour and for effects of light and shade, Sir Joshua united a strong perception of individual character,—a lively feeling of the quaint and grotesque in expression, and great mastery of execution. He had comparatively little knowledge of drawing, either as it regarded proportion or form. The beauty of some of his female faces and figures arises almost entirely from their softness and fleshiness. His pencil wanted firmness and precision. The expression, even of his best portraits, seldom implies either lofty or impassioned intellect or deli-

cate sensibility. He also wanted grace, if grace requires simplicity. The mere negation of stiffness and formality is not grace; for looseness and distortion are not grace. His favourite attitudes are not easy and natural, but the affectation of ease and nature. They are violent deviations from a right line. Many of the figures in his fancy-pieces are placed in postures in which they could not remain for an instant without extreme difficulty and awkwardness. We might instance the *Girl drawing with a pencil*, and some others. His portraits are his best pictures, and of these his portraits of men are the best; his pictures of children are the next in value. He had fine subjects for the former, from the masculine sense and originality of character of many of the persons whom he painted; and he had also a great advantage (as far as practice went) in painting a number of persons of every rank and description. Some of the finest and most interesting are those of Dr Johnson, Goldsmith (which is, however, too much a mere sketch), Baretti, Dr Burney, John Hunter, and the inimitable portrait of Bishop Newton. The elegant simplicity of character, expression, and drawing, preserved throughout the last picture, even to the attitude and mode of handling, discover the true genius of a painter. We also remember to have seen a print of Thomas Warton, than which nothing could be more characteristic or more natural. These were all Reynolds's intimate acquaintances, and it could not be said of them that they were men of "no mark or likelihood." Their traits had probably sunk deep into the artist's mind; he painted them as pure studies from nature, copying the real image existing before him, with all its known characteristic peculiarities; and, with as much wisdom as good-nature, sacrificing the graces on the altar of friendship. They are downright portraits, and nothing more, and they are valuable in proportion. In his portraits of women, on the contrary (with very few exceptions), Sir Joshua appears to have consulted either the vanity of his employers or his own fanciful theory. They have not the look of individual nature, nor have they, to compensate the want of this, either peculiar elegance of form, refinement of expression, delicacy of complexion, or gracefulness of manner. Vandyke's attitudes have been complained of as stiff and confined. Reynolds, to avoid this defect, has fallen into the contrary extreme of negligence and contortion. His female figures which aim at gentility, are twisted into that serpentine line, the idea of which he ridiculed so much in Hogarth. Indeed Sir Joshua, in his *Discourses* (see his account of Correggio), speaks of grace as if it were nearly allied to affectation. Grace signifies that which is pleasing and natural in the posture and motions of the human form, as Beauty is more properly applied to the form itself. That which is stiff, inanimate, and without motion, cannot, therefore, be graceful; but, to suppose that a figure, to be graceful, need only be put into some languishing or extravagant posture, is to mistake flutter and affectation for ease and elegance.

Sir Joshua's children, as we have said above, are among his *chef d'œuvres.* The faces of children have in general that want of precision of outline, that prominence of relief and strong contrast of colour, which were peculiarly adapted to his style of painting. The arch simplicity of expression, and the grotesque character which he has given to the heads of his children, were, however, borrowed from Correggio. His Puck is the most masterly of all these; and the colouring, execution, and character, alike exquisite. The single figure of the Infant Hercules is also admirable. Many of those to which his friends have suggested historical titles are mere common portraits or casual studies. Thus the Infant Samuel is an innocent little child, saying its prayers at the bed's feet: it has nothing to do with the story of the Hebrew prophet. The same objection will apply to many of his fancy-pieces and historical compositions. There is often no connection between the picture and the subject but the name. Even his celebrated Iphigenia (beautiful as she is, and prodigal of her charms) does not answer to the idea of the story. In drawing the naked figure, Sir Joshua's want of truth and firmness of outline, became more apparent; and his mode of laying on his colours, which, in the face and extremities, was relieved and broken by the abrupt inequalities of surface and variety of tints in each part, produced a degree of heaviness and opacity in the larger masses of flesh-colour, which can indeed only be avoided by extreme delicacy, or extreme lightness of execution.

Shall we speak the truth at once? In our opinion, Sir Joshua did not possess either that high imagination, or those strong feelings, without which no painter can become a poet in his art. His larger historical compositions have been generally allowed to be most liable to objection, in a critical point of view. We shall not attempt to judge them by scientific or technical rules, but make one or two observations on the character and feeling displayed in them. The highest subject which Sir Joshua has attempted was the *Count Ugolino,* and it was, as might be expected from the circumstances, a total failure. He had, it seems, painted a study of an old beggar-man's head: and some person, who must have known as little of painting as of poetry, persuaded the unsuspecting artist, that it was the exact expression of Dante's Count Ugolino, one of the most grand, terrific, and appalling characters in modern fiction. Reynolds, who knew nothing of the matter but what he was told, took his good fortune for granted, and only extended his canvass to admit the rest of the figures. The attitude and expression of Count Ugolino himself, are what the artist intended them to be, till they were pampered into something else by the officious vanity of friends—those of a common mendicant at the corner of a street, waiting patiently for some charitable donation. The imagination of the painter took refuge in a parish work-house, instead of ascending the steps of the Tower of Famine. The hero of Dante is a lofty, high-minded, and unprincipled Italian nobleman, who had betrayed his country to the enemy, and who, as a punishment for his crime, is shut up with his four sons in the dungeon of the citadel, where he shortly finds the doors barred against him, and food withheld. He in vain watches with eager feverish eye the opening of the door at the accustomed hour, and his looks turn to

stone; his children one by one drop down dead at his feet; he is seized with blindness, and, in the agony of his despair, he gropes on his knees after them,

——" Calling each by name
For three days after they were dead."

Even in the other world, he is represented with the same fierce, dauntless, unrelenting character, "gnawing the skull of his adversary, his fell repast." The subject of the *Laocoon* is scarcely equal to that described by Dante. The horror *there* is physical and momentary; in the other, the imagination fills up the long, obscure, dreary void of despair, and joins its unutterable pangs to the loud cries of nature. What is there in the picture to convey the ghastly horrors of the scene, or the mighty energy of soul with which they are borne? * His picture of *Macbeth* is full of wild and grotesque images; and the apparatus of the witches contains a very elaborate and well arranged inventory of dreadful objects. His Cardinal Beaufort is a fine display of rich mellow colouring; and there is something gentlemanly and Shakespearian in the King and the attendant Noblemen. At the same time, we think the expression of the Cardinal himself is too much one of physical horror, a canine gnashing of the teeth, like a man strangled. This is not the best style of history. Mrs Siddons as the *Tragic Muse*, is neither the tragic muse nor Mrs Siddons; and we have still stronger objections to *Garrick between Tragedy and Comedy*.

There is a striking similarity between Sir Joshua Reynolds's theory and his practice; and as each of these has been appealed to in support of the other, it is necessary that we should examine both. Sir Joshua's practice was generally confined to the illustration of that part of his theory, which relates to the more immediate imitation of nature, and it is to what he says on this subject, that we shall chiefly direct our observations at present.

He lays it down as a general and invariable rule, that "*the great style in art, and the most* PERFECT IMITATION OF NATURE, *consists in avoiding the details and peculiarities of particular objects.*" This sweeping principle he applies almost indiscriminately to *Portrait*, *History*, and *Landscape;* and he appears to have been led to the conclusion itself, from supposing the imitation of particulars to be inconsistent with general truth and effect. It appears to us, that the highest perfection of the art depends, not on separating but on uniting general truth and effect with individual distinctness and accuracy.

*First*, it is said, that the great style in painting, as it relates to the immediate imitation of external nature, consists in avoiding the details of particular objects. It consists neither in giving nor avoiding them, but in something quite different from both. Any one may avoid the details. So far, there is no difference between the *Cartoons*, and a common sign-painting. Greatness consists in giving the larger masses and proportions with truth;—this does not prevent giving the smaller ones too. The utmost grandeur of outline, and the broadest masses of light and shade, are perfectly compatible with the utmost minuteness and delicacy of detail, as may be seen in nature. It is not, indeed, common to see both qualities combined in the imitations of nature, any more than the combination of other excellences; nor are we here saying to which the principal attention of the artist should be directed; but we deny, that, considered in themselves, the absence of the one quality is necessary or sufficient to the production of the other.

If, for example, the form of the eye-brow is correctly given, it will be perfectly indifferent to the truth or grandeur of the design, whether it consists of one broad mark, or is composed of a number of hair-lines, arranged in the same order. So, if the lights and shades are disposed in fine and large masses, the *breadth* of the picture, as it is called, cannot possibly be affected by the filling up of those masses with the details, that is, with the subordinate distinctions which appear in nature. The anatomical details in Michael Angelo, the ever-varying outline of Raphael, the perfect execution of the Greek statues, do not destroy their symmetry or dignity of form; and, in the finest specimens of the composition of colour, we may observe the largest masses combined with the greatest variety in the parts of which those masses are composed.

The *gross* style consists in giving no details; the *finical* in giving nothing else. Nature contains both large and small parts, both masses and details; and the same may be said of the most perfect works of art. The union of both kinds of excellence, of strength with delicacy, as far as the limits of human capacity, and the shortness of human life would permit, is that which has established the reputation of the most successful imitators of nature. Farther, their most finished works are their best. The predominance, indeed, of either excellence in the best Masters, has varied according to their opinion of the relative value of these qualities,—the labour they had the time or the patience to bestow on their works,—the skill of the artist,—or the nature and extent of his subject. But, if the rule here objected to (that the careful imitation of the parts injures the effect of the whole), be once admitted, slovenliness would become another name for genius, and the most unfinished performance be the best. That such has been the confused impression left on the mind by the perusal of Sir Joshua Reynolds's Discourses, is evident from the practice, as well as conversation, of many (even eminent) artists. The late Mr Opie proceeded entirely on this principle. He left many admirable studies of portraits, particularly in what relates to the disposition and effect of light and shade; but he never finished any of the parts, thinking them beneath the attention

* Why does not the British Institution, instead of patronising pictures of the battle of Waterloo, of red coats, foolish faces, and labels of victory, offer a prize for a picture of the subject of Ugolino that shall be equal to the group of the Laocoon? *That* would be the way to do something, if there is any thing to be done by such patronage.

of a great artist. He went over the whole head the second day as he had done the first, and therefore made no progress. The picture at last, having neither the lightness of a sketch, nor the accuracy of a finished work, looked coarse, laboured, and heavy. Titian is the most perfect example of high finishing. In him the details are engrafted on the most profound knowledge of effect, and attention to the character of what he represented. His pictures have the exact look of nature, the very tone and texture of flesh. The variety of his tints is blended into the greatest simplicity. There is a proper degree both of solidity and transparency. All the parts hang together; every stroke tells, and adds to the effect of the rest. Sir Joshua seems to deny that Titian finished much; and says that he produced, by two or three strokes of his pencil, effects which the most laborious copyist would in vain attempt to equal. It is true, he availed himself in some degree of what is called *execution*, to facilitate his imitation of the details and peculiarities of nature; but it was to facilitate, not to supersede it. There can be nothing more distinct than execution and daubing. Titian, however, made a very moderate, though a very admirable use of this power; and those who copy his pictures will find that the simplicity is in the results, not in the details. To conclude our observations on this head, we will only add, that, while the artist thinks there is any thing to be done, either to the whole or to the parts of his picture, which can give it still more the look of nature, if he is willing to proceed, we would not advise him to desist. This rule is the more necessary to the young student, for he will relax in his attention as he grows older. And again, with respect to the subordinate parts of a picture, there is no danger that he will bestow a disproportionate degree of labour upon them, because he will not feel the same interest in copying them, and because a much less degree of accuracy will serve every purpose of deception.

*Secondly*, with regard to the imitation of expression, we can hardly agree with Sir Joshua, that "the perfection of portrait-painting consists in giving the general idea or character without the individual peculiarities." No doubt, if we were to choose between the general character, and the peculiarities of feature, we ought to prefer the former. But, they are so far from being incompatible with, that they are not without some difficulty distinguishable from, each other. There is a general look of the face, a predominant expression arising from the correspondence and connection of the different parts, which it is of the first and last importance to give; and without which, no elaboration of detached parts, or marking of the peculiarities of single features, is worth any thing; but which, at the same time, is not destroyed, but assisted by the careful finishing, and still more by giving the exact outline of each part.

It is on this point that the modern French and English schools differ, and (in our opinion) are both wrong. The English seem generally to suppose, that if they only leave out the subordinate parts, they are sure of the general result. The French, on the contrary, as erroneously imagine, that, by attending successively to each separate part, they must infallibly arrive at a correct whole; not considering that, besides the parts, there is their relation to each other, and the general expression stamped upon them by the character of the individual, which to be seen must be felt; for it is demonstrable, that all character and expression, to be adequately represented, must be perceived by the mind, and not by the eye only. The French painters give only lines and precise differences; the English only general masses, and strong effects. Hence the two nations reproach one another with the difference of their styles of art, —the one as dry, hard, and minute,—the other as gross, gothic, and unfinished; and they will probably remain for ever satisfied with each other's defects, as they afford a very tolerable fund of consolation on either side.

Much has been said of *historical portrait;* and we have no objection to this phrase, if properly understood. The giving historical truth to a portrait, means, then, the representing the individual under one consistent, probable, and striking view; or showing the different features, muscles, &c. in one action, and modified by one principle. A portrait thus painted may be said to be *historical;* that is, it carries internal evidence of truth and propriety with it; and the number of individual peculiarities, as long as they are true to nature, cannot lessen, but must add to the strength of the general impression.

It might be shown (if there were room in this place) that Sir Joshua has constructed his theory of the *ideal* in art, upon the same mistaken principle of the negation or abstraction of *particular nature.* The *ideal* is not a negative but a positive thing. The leaving out the details or peculiarities of an individual face, does not make it one jot more ideal. To paint history, is to paint nature as answering to a general, predominant, or preconceived idea in the mind, of strength, beauty, action, passion, thought, &c.; but the way to do this is not to leave out the details, but to incorporate the general idea with the details;—that is, to show the same expression actuating and modifying every movement of the muscles, and the same character preserved consistently through every part of the body. Grandeur does not consist in omitting the parts, but in connecting all the parts into a whole, and in giving their combined and varied action: abstract truth or ideal perfection does not consist in rejecting the peculiarities of form, but in rejecting all those which are not consistent with the character intended to be given; and in following up the same *general idea* of softness, voluptuousness, strength, activity, or any combination of these through every ramification of the frame. But these modifications of form or expression can only be learnt from nature, and therefore the perfection of art must always be sought in nature. The ideal properly applies as much to the *idea* of ugliness, weakness, folly, meanness, vice, as of beauty, strength, wisdom, magnanimity, or virtue. The antique heads of fauns and satyrs, of Pan or Silenus, are quite as ideal as those of the Apollo or Bacchus; and Hogarth adhered to an idea of humour in his faces, as Raphael did to an idea of sentiment. But Raphael found the character of sentiment in nature as much as Hogarth did that of humour; otherwise

Fine Arts.

neither of them would have given one or the other with such perfect truth, purity, force, and keeping. Sir Joshua Reynolds's *ideal*, as consisting in a mere negation of individuality, bears just the same relation to real beauty or grandeur as caricature does to true comic character. *

Present state of British Art.

It is owing either to a mistaken theory of elevated art, or to the want of models in nature, that the English are hitherto without any painter of serious historical subjects, who can be placed in the first rank of genius. Many of the pictures of modern artists have shown a capacity for correct and happy delineation of actual objects and domestic incidents, only inferior to the masterpieces of the Dutch School. We might here mention the names of Wilkie, Collins, Heaphy, and many others. We have portrait-painters, who have attained to a very high degree of excellence in all the branches of their art. In landscape, Turner has shown a knowledge of the effects of air, and of powerful relief in objects, which was never surpassed. But in the highest walk of art—in giving the movements of the finer or loftier passions of the mind, this country has not produced a single painter, who has made even a faint approach to the excellence of the great Italian painters. We have, indeed, a good number of specimens of the clay-figure, the anatomical mechanism, the regular proportions measured by a two-foot rule;—large canvasses, covered with stiff figures, arranged in deliberate order, with the characters and story correctly expressed by uplifted eyes or hands, according to old receipt-books for the passions;—and with all the hardness and inflexibility of figures carved in wood, and painted over in good strong body colours, that look "as if some of nature's journeymen had made them, and not made them well." But we still want a Prometheus to give life to the cumbrous mass, to throw an intellectual light over the opaque image,—to embody the inmost refinements of thought to the outward eye,—to lay bare the very soul of passion. That picture is of little comparative value, which can be completely *translated* into another language,—of which the description in a common catalogue conveys all that is expressed by the picture itself; for it is the excellence of every art to give what can be given by no other, in the same degree. Much less is that picture to be esteemed, which only injures and defaces the idea already existing in the mind's eye,—which does not come up to the conception which the imagination forms of the subject, and substitutes a dull reality for high sentiment; for the art is in this case an encumbrance, not an assistance, and interferes with, instead of adding to, the stock of our pleasurable sensations. But we should be at a loss to point out (we will not say any English picture, but certainly) any English painter, who, in heroic and classical composition, has risen to the height of his subject, and answered the expectation of the well-informed spectator, or excited the same impression by visible means, as had been already excited by words, or by reflection. † That this inferiority in English art is not owing to a deficiency of genius, imagination, or passion, is proved sufficiently by the works of our poets and dramatic writers, which, in loftiness and force, are not surpassed by those of any other nation. But whatever may be the depth of internal thought and feeling in the English character, it seems to be *more internal*; and (whether this is owing to habit, or physical constitution) to have, comparatively, a less immediate and powerful communication with the organic expression of passion,—which exhibits the thoughts and feelings in the countenance, and furnishes matter for the historic muse of painting. The English artist is instantly sensible that the flutter, grimace, and extravagance of the French physiognomy, are incompatible with high history; and we are at no loss to explain in this way, that is, from the defect of living models, how it is that the productions of the French school are marked with all the affectation of national caricature, or sink into tame and lifeless imitations of the antique. May we not account satisfactorily for the general defects of our own historic productions, in a similar way,—from a certain inertness and constitutional phlegm, which does not habitually impress the workings of the mind in correspondent traces on the countenance, and which may also render us less sensible of these outward and visible signs of passion, even when they are so impressed there? The irregularity of proportion, and want of symmetry, in the structure of the national features, though it certainly enhances the difficulty of infusing natural grace and grandeur into the works of art, rather accounts for our not having been able to attain the exquisite refinements of Grecian sculpture, than for our not having rivalled the Italian painters in expression.

Mr West does not form an exception to, but a confirmation of, these general observations. His pictures have all that can be required in what relates to the composition of the subject; to the regular arrangement of the groups; the anatomical proportions of the human body; and the technical knowledge of expression,—as far as expression is reducible to abstract rules, and is merely a vehicle for the telling of a story; so that anger, wonder, sorrow, pity, &c. have each their appropriate and well-known designations. These, however, are but the instrumental parts of the art, the means, not the end; but beyond these, Mr West's pictures do not go. They never "snatch a grace beyond the reach of art." They exhibit the *mask*, not the *soul* of expression. We doubt, whether, in the entire range of Mr West's productions, meritorious and admirable as the design and composition often are, there is to be found one truly fine head. They display a total want of gusto. In Raphael, the same divine spirit breathes through every part; it either agitates the inmost frame, or plays in gentle undulations on the trembling surface. Whether we see his figures bending with all the blandishments of maternal love, or standing in the motionless silence of thought, or hurried into the tumult of action, the

* This subject of the *Ideal* will be resumed, and more particularly enlarged upon, under that head.

† If we were to make any qualification of this censure, it would be in favour of some of Mr Northcote's compositions from early English history.

whole is under the impulse of deep passion. But Mr West sees hardly any thing in the human face but bones and cartilages; or, if he avails himself of the more flexible machinery of nerves and muscles, it is only by rule and method. The effect is not that which the soul of passion impresses on the countenance, and which the soul of genius alone can seize; but such as might, in a good measure, be given to wooden puppets or pasteboard figures, pulled by wires, and taught to open the mouth, or knit the forehead, or raise the eyes in a very scientific manner. In fact, there is no want of art or learning in his pictures, but of nature and feeling.

Means of promoting the Fine Arts.

It is not long ago that an opinion was very general, that all that was wanting to the highest splendour and perfection of the arts in this country might be supplied by Academies and public institutions. We believe the most sanguine promoters of this scheme have at present relaxed in their zeal. There are *three* ways in which Academies and public institutions may be supposed to promote the fine arts; either by furnishing the best models to the student; or by holding out immediate emolument and patronage; or by improving the public taste. We shall bestow a short consideration on the influence of each.

First, a constant reference to the best models of art necessarily tends to enervate the mind, to intercept our view of nature, and to distract the attention by a variety of unattainable excellence. An intimate acquaintance with the works of the celebrated masters may indeed add to the indolent refinements of taste, but will never produce one work of original genius, one great artist. In proof of the general truth of this observation, we might cite the history of the progress and decay of art in all countries where it has flourished. It is a little extraordinary, that if the real sources of perfection are to be sought in Schools, in Models, and Public Institutions, that wherever schools, models, and public institutions have existed, there the arts should regularly disappear,—that the effect should never follow from the cause.

The Greek statues remain to this day unrivalled,—the undisputed standard of the most perfect symmetry of form. In Italy the art of painting has had the same fate. After its long and painful struggles in the time of the earlier artists, Cimabue, Ghirlandaio, Massacio, and others, it burst out with a light almost too dazzling to behold, in the works of Titian, Michael Angelo, Raphael, and Correggio; which was reflected, with diminished lustre, in the productions of their immediate disciples; lingered for a while with the school of the Carraccis, and expired with Guido Reni. From that period, painting sunk to so low a state in Italy as to excite only pity or contempt. There is not a single name to redeem its faded glory from utter oblivion. Yet this has not been owing to any want of Dilettanti and Della Cruscan societies,—of academies of Florence, of Bologna, of Parma, and Pisa,—of honorary members and Foreign Correspondents,—of pupils and teachers, professors and patrons, and the whole busy tribe of critics and connoisseurs.

What is become of the successors of Rubens, Rembrandt, and Vandyke? What have the French Academicians done for the arts; or what will they ever do, but add intolerable affectation and grimace to centos of heads from the antique, and caricature Greek forms by putting them into opera attitudes? Nicholas Poussin is the only example on record, in favour of the contrary theory, and we have already sufficiently noticed his defects. What extraordinary advances have we made in our own country in consequence of the establishment of the Royal Academy? What greater names has the English school to boast than those of Hogarth, Reynolds, and Wilson, who created it? Even the venerable President of the Royal Academy was one of its founders.

Again, we might cite, in support of our assertion, the works of Carlo Maratti, of Raphael Mengs, or of any of the effeminate school of critics and copyists, who have attempted to blend the borrowed beauties of others in a perfect whole. What do they contain, but a negation of every excellence which they pretend to combine? The assiduous imitator, in his attempts to grasp all, loses his hold of that which was placed within his reach, and, from aspiring at universal excellence, sinks into uniform mediocrity. The student who has models of every kind of excellence constantly before him, is not only diverted from that particular walk of art, in which, by patient exertion, he might have obtained ultimate success, but, from having his imagination habitually raised to an overstrained standard of refinement, by the sight of the most exquisite examples in art, he becomes impatient and dissatisfied with his own attempts, determines to reach the same perfection all at once, or throws down his pencil in despair. Thus the young enthusiast, whose genius and energy were to rival the great Masters of antiquity, or create a new æra in the art itself, baffled in his first sanguine expectations, reposes in indolence on what others have done; wonders how such perfection could have been achieved,—grows familiar with the minutest peculiarities of the different schools,—flutters between the splendour of Rubens, and the grace of Raphael, and ends in nothing. Such was not Correggio. He saw and felt for himself; he was of no school, but had his own world of art to create. That image of truth and beauty, which existed in his mind, he was forced to construct for himself, without rules or models. As it had arisen in his mind from the contemplation of nature, so he could only hope to embody it to others, by the imitation of nature. We can conceive the work growing under his hands by slow and patient touches, approaching nearer to prefection, softened into finer grace, gaining strength from delicacy, and at last reflecting the pure image of nature on the canvass. Such is always the true progress of art; such are the necessary means by which the greatest works of every kind have been produced. They have been the effect of power gathering strength from exercise, and warmth from its own impulse—stimulated to fresh efforts by conscious success, and by the surprise and strangeness of a new world of beauty, opening to the delighted imagination. The triumphs of art were victories over the difficulties of art; the prodigies of genius, the result of that strength which had grappled with nature. Titian copied even a plant or a piece of common drapery from the objects

themselves; and Raphael is known to have made elaborate studies of the principal heads in his pictures. All the great painters of this period were thoroughly grounded in the first principles of their art; had learned to copy a face, a hand, or an eye, and had acquired patience to finish a single figure, before they undertook to paint extensive compositions. They knew that though Fame is represented with her head above the clouds, her feet rest upon the earth. Genius can only have its full scope, where, though much may have been done, more remains to do; where models exist chiefly to show the deficiencies of art, and where the perfect idea is left to be filled up in the painter's imagination. When once the stimulus of novelty and of original exertion is wanting, generations repose on what has been done for them by their predecessors, as individuals, after a certain period, rest satisfied with the knowledge they have already acquired.

With regard to the pecuniary advantages arising from the public patronage of the arts;—the plan unfortunately defeats itself; for it multiplies its objects faster than it can satisfy their claims; and raises up a swarm of competitors for the prize of genius from the dregs of idleness and dulness. The real patron is anxious to reward merit, not to encourage gratuitous pretensions to it; to see that the man of genius *takes no detriment*, that another Wilson is not left to perish for want;—not to propagate the breed of embryo candidates for fame. Offers of public and promiscuous patronage can in general be little better than a species of intellectual seduction, administering provocatives to vanity and avarice, and leading astray the youth of the nation by fallacious hopes, which can scarcely ever be realized. At the same time, the good that might be done by private taste and benevolence, is in a great measure defeated. The moment that a few individuals of discernment and liberal spirit become members of a public body, they are no longer any thing more than parts of a machine, which is usually wielded at will by some officious, overweening pretender; their good-sense and good-nature are lost in a mass of ignorance and presumption; their names only serve to reflect credit on proceedings in which they have no share, and which are determined on by a majority of persons who have no interest in the arts but what arises from the importance attached to them by regular organization, and no opinions but what are dictated to them by some self-constituted judge. As far as we have had an opportunity of observing the conduct of such bodies of men, instead of taking the lead of public opinion, of giving a firm, manly, and independent tone to that opinion, they make it their business to watch all its caprices, and follow it in every casual turning. They dare not give their sanction to sterling merit, struggling with difficulties, but take advantage of its success, to reflect credit on their own reputation for sagacity. Their taste is a servile dependant on their vanity, and their patronage has an air of pauperism about it. Perhaps the only public patronage which was ever really useful to the arts, or worthy of them, was that which they received first in Greece, and afterwards in Italy, from the religious institutions of the country; when the artist felt himself, as it were, a servant at the altar; when his hand gave a visible form to Gods or Heroes, Angels or Apostles; and when the enthusiasm of genius was exalted by mingling with the flame of national devotion. The artist was not here degraded, by being made the dependant on the caprice of wealth or fashion, but felt himself at once the servant and the benefactor of the public. He had to embody, by the highest efforts of his art, subjects which were sacred to the imagination and feelings of the spectators; there was a common link, a mutual sympathy between them in their common faith! Every other mode of patronage, but that which arises, either from the general institutions and manners of a people, or from the real unaffected taste of individuals, must, we conceive, be illegitimate, corrupted in its source, and either ineffectual or injurious to its professed object.

Lastly, Academies and Institutions may be supposed to assist the progress of the fine arts, by promoting a wider taste for them.

In general, it must happen in the first stages of the arts, that as none but those who had a natural genius for them, would attempt to practise them,—so none but those who had a natural taste for them, would pretend to judge of or criticise them. This must be an incalculable advantage to the man of true genius; for it is no other than the privilege of being tried by his peers. In an age when connoisseurship had not become a fashion; when religion, war, and intrigue, occupied the time and thoughts of the great, only those minds of superior refinement would be led to notice the works of art, who had a real sense of their excellence; and, in giving way to the powerful bent of his own genius, the painter was most likely to consult the taste of his judges. He had not to deal with pretenders to taste, through vanity, affectation, and idleness. He had to appeal to the higher faculties of the soul,—to that deep and innate sensibility to truth and beauty, which required only fit objects to have its enthusiasm excited,—and to that independent strength of mind, which, in the midst of ignorance and barbarism, hailed and fostered genius, wherever it met with it. Titian was patronised by Charles V. Count Castiglione was the friend of Raphael. These were true patrons and true critics; and, as there were no others (for the world, in general, merely looked on and wondered), there can be little doubt that such a period of dearth of factitious patronage would be most favourable to the full developement of the greatest talents, and to the attainment of the highest excellence.

By means of public institutions, the number of candidates for fame, and pretenders to criticism, is increased beyond all calculation, while the quantity of genius and feeling remain much the same as before; with these disadvantages, that the man of original genius is often lost among the crowd of competitors who would never have become such, but from encouragement and example, and that the voice of the few whom nature intended for judges, is apt to be drowned in the noisy and forward suffrages of shallow smatterers in Taste. (z.)

ASIA
English Miles.
100 200 300 400 800
EUROPE
AFRICA
ARABIA
EGYPT
MEDITERRANEAN SEA
BLACK SEA
CASPIAN SEA
PERSIA
BELOOCHISTAN
TIBET
CHINA
BENGAL
BAY OF BENGAL
Gulf of Siam
Cambodia
CHINA SEA
PHILIPPINE ISLANDS
SEA OF JAPAN
JAPAN ISLANDS
SEA OF OKHOTSK
Kurili Isles
Novaya Zemlia
Sea of Kara
PACIFIC OCEAN
INDIAN
Laccadives
Maldives
CEYLON
Nicobar Isles
Formosa
Hainan
Borneo
Longitude East 60 from Greenwich

ASIA. Under this head in the *Encyclopædia*, there is a general survey of Asia and its Divisions, and of the prevailing manners, religions, and institutions of its chief Communities. We have, in this volume, already treated in a general way of those grand Divisions of our Globe, AFRICA and AMERICA; and notwithstanding the extent of the space devoted to ASIA in the body of the work, the recent acquisitions to our knowledge of that Continent might also, without impropriety, have been made the subject of a supplemental article in this place; but as these additions are more susceptible, than in the case either of AFRICA or AMERICA, of being separately introduced under the names of particular Countries and Islands, we shall, in order to save room for other matters, adopt that course in regard to the recent improvements in Asiatic geography.

It is proper to mention, that the best of the later Geographers have separated a vast number of Islands formerly described as *Asiatic* Islands, from that Continent, and arranged them with a multitude of other Countries and Islands to the south of Asia, and in the Pacific Ocean, under the two new divisions of AUSTRALASIA and POLYNESIA. The grounds of this arrangement, which was first suggested by the learned President des Brosses, are stated with sufficient clearness by Mr Pinkerton, in his introductory observations on the ASIATIC *Islands;* and the reader of this work will also find them explained under our articles on AUSTRALASIA and POLYNESIA.

We may here observe generally, that a great deal yet remains to be done in order to complete the geography of Asia. Its central mountains, perhaps the most stupendous masses on the Globe, present a wholly unexplored field of inquiry; the origin, the course, and progressive increase of some of its greatest rivers, remain still to be ascertained; and scarce any of its internal seas, except the Caspian, has been the subject of actual survey. The interior regions of Siberia require much illustration. The same may be said, and perhaps in a still stronger degree, of the central parts of Tartary, of the northern parts of China, and of those of India. As to the probable *population* of this Continent, it is enough to say, that differences of a hundred millions exist in regard to that of China alone. From all this it appears how very defective our knowledge is of this important Division of the Globe, and what a vast and varied field it still presents to incite the inquiries, and reward the enterprise of future Explorers.

ASPHALTITES, a Lake of Judea, near Jerusalem, so called from the *Bitumen* which floats upon its surface; and equally well known under the name of the *Dead Sea;*—a name associated with many fables, and derived from a long standing belief, that no creature could live in its waters, or within the reach of its pestiferous exhalations.

The reader will find the substance of the ancient accounts, and those of the earlier Travellers in regard to this famous Lake, in the article under its name in the *Encyclopædia;* we shall therefore confine ourselves in this place, to such authentic particulars, as have been furnished by the observations and inquiries of those who have recently visited the *Holy Land.*

This Lake is supposed to be from sixty to seventy miles in length, and from ten to twenty in breadth. It is curved like a bow, and placed between two ranges of mountains, of lofty and majestic appearance. But the grandeur of its features is blended with an air of sadness and desolation, which seems to accord well with the marvellous stories associated with its name.

Some of these fables have an obvious foundation in its physical properties. Its taste is remarkably bitter, saline, and pungent; and hence has arisen the notion of its pestiferous vapours and deadly influence. We are told even by Volney, that its waters are destructive both of animal and vegetable life; but he denies that its vapours have any deadly quality, for swallows, he says, are often seen to skim its surface without injury. M. De Chateaubriand, who visited its shores in 1807, with an imagination abundantly disposed to the marvellous, has given the first decided testimony that it abounds with fish. He reached the Lake when it was already dark, and passed the night among some Arab tents. "About midnight," says he, "I heard a noise upon the Lake, and was told by the Bethlehemites who accompanied me, that it proceeded from *legions of small fish* which come out and leap about on the shore." This interesting Traveller speaks in the following terms of its saline properties: "The first thing I did on alighting was to walk into the Lake up to my knees, and to taste the water. I found it impossible to keep it in my mouth. It far exceeds that of the sea in saltness, and produces upon the lips the effect of a strong solution of alum. Before my boots were completely dry, they were covered with salt: our clothes, our hats, our hands, were in less than three hours impregnated with this mineral."

The common story, that nothing will sink in it, is to be ascribed to the extraordinary density of its waters. Bodies follow the general law, and sink or swim, according to the proportion of their gravity to the gravity of the water of the Lake; but its specific gravity is such, that a man may lie upon its surface motionless, without danger of sinking. This effect was experienced by Pococke, and by a Scottish traveller, Mr Gordon of Clunie, who also bathed in it. This gentleman brought home a phial of its water, and Dr Marcet found its specific gravity to be 1.211; a degree of density, says he, "not to be met with in any other natural water." Dr Marcet was employed to analyse Mr Gordon's specimen, which that gentleman had presented to Sir Joseph Banks in 1807; and the whole process, with its results, is detailed in the *Philosophical Transactions* for that year. It was found that 100 grains of the water contains the following substances, in the under-mentioned proportions:

| | Grains. |
|---|---|
| Muriat of lime . . . . | 3,920 |
| Muriat of magnesia . . . | 10,246 |
| Muriat of soda . . . . | 10,360 |
| Sulphat of lime . . . | 0,054 |
| | 24,580 |

The water of the Dead Sea had been previously analysed by Messrs Macquer, Lavoisier, and Sage, of whose experiments an account was published in the *Mémoires de l'Academie des Sciences* for the year 1778. Their analysis afforded results greatly different from those obtained by Dr Marcet, which that gentleman ascribes to some inaccuracy in their mode of operating. We find, however, that the processes employed by Dr Marcet have been called in question, and the accuracy of his proportions denied by a very skilful Chemist, who subsequently instituted an analysis of the Dead Sea water. We allude to Klaproth, who procured a specimen brought from the East by the Abbé Mariti, and whose analysis offered the following proportions:

| | |
|---|---|
| Muriat of magnesia | 24,20 |
| Muriat of lime | 10,60 |
| Muriat of soda | 7,80 |
| | 42,60 |
| Water | 57,40 |
| | 100. |

Klaproth also found the specific gravity to be 1,245 instead of 1,211; agreeing in this respect more nearly with Macquer and Lavoisier, who stated it at 1,240. The specific gravity of Dr Marcet's specimen may, however, have been less, from its having been taken from the Lake, not far from the influx of the Jordan, on which account it might be somewhat diluted.

Dr Clarke mentions, that the inhabitants of the country still regard the Dead Sea with feelings of terror This may be owing to the tradition that its waters cover the engulphed cities of Sodom and Gomorrah, or to the ideas entertained of the peculiar insalubrity of its exhalations. It is much to be regretted, that this Traveller was prevented by the Arabs, who infested the neighbourhood, from exploring the Lake, which he only saw at some distance; as with his attainments, he could not have failed to gather some interesting information regarding its natural history. Though M. de Chateaubriand, a few years after, succeeded in reaching its banks, he could only, owing to the same cause, remain a few hours; and besides, however capable of interesting his readers, he was not so well qualified for accurate or scientific observation. While some of his facts run counter to the ancient fables, others seem calculated to add to the list; as, when he discovers a resemblance between the noise of its waves, and the stiffled clamours of the people whom they engulphed! The following passage, however, is of the antifabulous kind, and contains some information which cannot but be acceptable to our readers. "There is scarcely any one who has not heard of the famous tree of Sodom; a tree, said to produce an apple pleasing to the eye, but bitter to the taste, and full of ashes. Tacitus, in the fifth book of his *History*, and Josephus, in his *Jewish war*, are, I believe, the two first authors that made mention of the singular fruits of the Dead Sea. Foulcher de Chartres, who travelled in Palestine about the year 1100, saw the deceitful apple, and compared it to the pleasures of the world. Since that period, some writers, as Ceverius de Vera, Baumgarten, de la Vallée, Troilo, and certain Missionaries, confirm Foulcher's statement; others, as Reland, Father Neret, and Maundrell, are inclined to believe that this fruit is but a poetic image of our false joys; while others again, as Pococke and Shaw, absolutely question its existence.



"Amman seemed to remove the difficulty. He gave a description of the tree, which, according to him, resembles the hawthorn. "The fruit," says he, "is a small apple, of a beautiful colour."

"Hasselquist, the Botanist, followed, and he tells a totally different story. The apple of Sodom, as we are informed by him, is not the fruit either of a tree or of a shrub, but the production of the *Solanum melongena* of Linnæus. "It is found in great abundance," says he, "round Jericho, in the valleys near the Jordan, and in the neighbourhood of the Dead Sea. It is true that these apples are sometimes full of *dust;* but this appears only when the fruit is attacked by an insect *(tenthredo)*, which converts the whole of the inside into dust, leaving nothing but the rind entire, without causing it to lose any of its colour."

"Who would not imagine, after this, that the question had been set completely at rest, by the authority of Hasselquist, and the still greater authority of Linnæus, in his *Flora Palæstina?* No such thing. M. Seetzen, also a man of science, and the most modern of all Travellers, since he is still in Arabia, does not agree with Hasselquist in regard to the *Solanum Sodomeum*. "I saw," says he, "during my stay at Karrak, in the house of the Greek clergyman of that town, a species of cotton resembling silk. This cotton, as he told me, grows in the plain of El Gor, near the southern extremity of the Dead Sea, on a tree like a fig-tree, called *Abescha-ez;* it is found in a fruit resembling the pomegranate. It struck me, that this fruit, which has no pulp or flesh in the inside, and is unknown in the rest of Palestine, might be the celebrated apple of Sodom."

"Here I am thrown into an awkward dilemma; for I too have the vanity to imagine that I have discovered the long-sought fruit. The shrub which bears it grows two or three leagues from the mouth of the Jordan: it is thorny, and has small taper leaves. It bears a considerable resemblance to the shrub described by Amman; and its fruit is exactly like the little Egyptian lemon, both in size and colour. Before it is ripe, it is filled with a corrosive and saline juice; when dried it yields a blackish seed, which may be compared to ashes, and which in taste resembles bitter pepper." See Chateaubriand's *Travels in Greece, Palestine, Egypt, and Barbary*.—Dr Clarke's *Travels in Greece, Egypt, and the Holy Land*.—*Philosophical Transactions* of the Royal Society of London for 1807.—Klaproth, *Beiträge zur Chemischen Kenntniss der Mineral Körper*. B. 5. p. 185. Berlin, 1810.

ASSAM, a kingdom of Asia, situated on the north-west of Bengal, between the 25th and 26th degrees

of north latitude, and extending from 94 to 99 degrees of east longitude. The exact limits, however, are not precisely ascertained; for this country is very little known to Europeans, and what respects its extent to the east is at present to be understood as partly conjectural. Assam is an immense valley, about 700 miles in length, by between 60 and 80 in breadth, surrounded by high hills on all sides, and interspersed with numerous eminences in the interior, universally susceptible of cultivation. The whole superficies is calculated at 60,000 square miles, a large portion of which is occupied by woods and rivers, and the remainder consists chiefly of fertile soil; but this calculation is exclusive of any conquered countries, and of the territories that extend in every line beyond the hills. Part of the kingdom is mountainous, particularly what is called Higher or Upper Assam; and part of it is low and level, containing extensive plains, subject to frequent inundations in the rainy seasons. The general position of this great valley, as well as of the mountains and rivers traversing it, is in a direction from north to south. It is bounded on the north by the successive ranges of the mountains of Bootan, Anka, Duffala, and Miree; and, on the south, by the Garrow Mountains, which rise higher as they recede northward, and change their name to Naga at a place called Coliabark. Probably the rivers intersecting Assam are more numerous than those of any other country of equal extent in the universe, from its being completely environed by hills. The rains are collected together, and, pouring down in irresistible torrents, swell the waters below, until the plains are covered by the inundation. The valley is divided throughout, by the Burhampooter, into two parts nearly equal; and many Islands, some of them very large, are formed by it, and by the confluence and mutual intersection of other rivers. They contribute alike to fertilize the ground, and to facilitate the intercourse of the inhabitants, as they are navigable by flat-bottomed boats, capable of transporting them and their property. Of these rivers, not less than sixty-one are known and distinguished by particular names, of which thirty-four flow from the northern, and twenty-four from the southern mountains; but the source of the Burhampooter is scarcely yet ascertained, nor were Europeans acquainted with its course until traced by Major Rennell. However, it seems to rise beyond the confines of Assam. As the rivers change their names at different places, it is sometimes difficult to discover those that are meant in description; and their size may be estimated differently, according as they are examined in the time of inundation, or otherwise. The length of the course, and the sinuosities of many, are remarkable. The Dhekow or Degoo, by the size of which Geographers are accustomed to compare the other rivers, rises very far to the eastward of the Naga mountains, which it traverses for a considerable distance, and then winds 200 miles through the valley from its entrance, until joining the Dehingh, a great branch of the Burhampooter. Another river, the Dekrungh, rises in the Duffala mountains, and, exhibiting a large stream, occupies 100 miles in its windings, before falling into the Burhampooter, though the direct line does not exceed 25. Notwithstanding its depth and rapidity, it is navigable by small boats. The river Pisola, which likewise rises in the Duffala mountains, pursues a winding course of 60 miles, and, during the rainy season, may be ascended to the base of the mountains; but it is not navigable after the inundations subside. The rivers to the south are never so rapid, as the inundations commence from the northern rivers. Both these and the Burhampooter are filled, so that the water has no considerable current until May or June, when the current is rather stronger from the south in the season of the rains, though the increase is not very material, as the large river at this period is always pretty full, and checks the rapidity of all the southern rivers.

Among the numerous Islands of different dimensions, formed by the intersection and confluence of the rivers, is Majuli, or the Great Island, as it is called by pre-eminence, which appears to constitute one of the chief political divisions of the kingdom. This Island extends 100 miles in length, by about 60 in breadth; and is formed by the river Dehingh on the west, and the Looicheh on the north; but independent of these great aquatic boundaries, it is intersected by numerous streams, so that it, in fact, consists of a cluster of lesser Islands, and some Islets, besides, near the banks, which in the principal rivers are dry only while no inundations prevail. The other Islands throughout Assam are of all different dimensions, from the most inconsiderable size to six, ten, or twenty miles and more in length. A correct picture of the country may thus be figured as being an extensive valley, environed by mountains, full of rivers and level plains. While the rivers constitute its defence, and promote the convenience of its inhabitants, as also contribute to fertilize the soil overflowed by their inundations, they interrupt occasional intercourse from their magnitude and rapidity; and it is to be observed, that there is only one stone-bridge in the kingdom, which was erected at Rungpoon by workmen brought from Bengal. Besides the Great Island or Majuli, Assam contains other two political divisions. Ootrecole, Uttarcul, or Ootreparah; Deccancole, Dacshincul, or Deccanparah; the former of which, Ootrecole, denotes the country lying north of the Burhampooter; the latter, Deccancole, that to the south. And it is further to be remarked, that Majuli is formed by great arms of the same river, though passing by different names.

The political subdivisions of Assam are apparently almost as numerous as the more important natural ones; but the province of Camroop in Ootrecole, is one of the largest and the best known by description, at least, to Europeans. It formerly gave name to an extensive kingdom, of which the capital seems to have been Rangmattee, beyond the present western confines of Assam. It now stretches about 100 miles in length, and its breadth, from the banks of the Burhampooter to the foot of the mountains, is 40 miles. There are no strong places within its limits, and its chief town is Cotta. The district Summooria, occupies the southern banks of the Burhampooter; and the district of Nodooaria, which extends to the eastward, is divided into nine shares or districts, held by so many rajahs, though under the rule of only two.

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Valuable minerals are found in Assam; the whole country produces gold in abundance, insomuch that from 12.000 to 20,000 of the inhabitants are said to have been constantly employed in collecting it. This precious metal is found in all the rivers flowing from the northern mountains, but it is of different quality in purity and colour, and also in malleability. That which is obtained in the Dekrungh is particularly celebrated; and it is distinguished by a higher colour than what is found in the Burhampooter and other rivers. Gold is more abundant in the bed of the Burrowgown than in the channel of most rivers, but is thought of inferior colour and quality. What is procured from the bed of the Burrogown is esteemed as much superior even to the gold of the Dekrungh; the colour is deeper and more vivid, and is compared by the natives to fire; it is likewise deemed of more intrinsic value, and always bears a greater price in Assam. The greatest quantities of gold are found nearest the mountains, which probably indicates that it is carried down from them by the torrents, but it is never sought in the beds of the southern rivers. In the others, as those flowing from the north, it is of paler colour, less pure, and in smaller quantity, according as it is recovered from the mines farther to the east. The persons employed in collecting it, pay a small tribute to the Sovereign in proportion to their success. Besides this precious metal, there are mines of silver, lead, and iron, which all belong to the King, and are wrought for his advantage alone. Rock-salt is dug out of the earth, but it is bitter, and of indifferent quality. The vegetable products of Assam are abundant, and of excellent quality; thick and extensive forests cover a large portion of the country; cultivated fields, especially of rice, the staple grain for subsistence, and the finest fruits, are generally to be seen. A Persian writer, Mahommed Cazim, in describing this country, makes some observations on its general appearance, which, as he was hostile to the inhabitants, may probably merit the greater confidence. He speaks of Majuli as "an Island well inhabited, and in an excellent state of agriculture; it contains a spacious, clear, and pleasant country, extending to the distance of about 100 miles. The cultivated part is bounded by a thick forest, which harbours elephants, and where these animals may be caught, as well as in four or five other forests of Assam. If there be occasion for them, five or six hundred elephants may be procured in a year. Across the Dhonec, which is the side of Ghergong, is a wide agreeable level country, that delights the heart of the beholder. The whole face of it is marked with population and tillage, and it presents, on every side, charming prospects of ploughed fields, harvests, gardens, and groves. From the village of Salagerah to the city of Ghergong, a space of about 100 miles, is filled with such an uninterrupted range of gardens, plentifully stocked with fruit-trees, that it appears as one garden. Within them are the houses of peasants, and a beautiful assemblage of coloured and fragrant herbs, and of garden and wild flowers blowing together. As the country is overflowed in the rainy season, a high and broad causeway has been raised for the convenience of travellers, from Salagerah to Ghergong, which is the only uncultivated ground that is to be seen. Each side of this road is planted with shady bamboos, the tops of which meet and are entwined. Among the fruits which this country produces, are mangoes, plantains, jacks, oranges, citrons, limes, and punialeh, a species of amleh, which has such an excellent flavour, that every person who tastes it, prefers it to the plum. There are also cocoa-nut trees, pepper, vines, areca trees, and the sadij (an aromatic leaf), in great plenty. Sugar-cane excels in softness and sweetness, and is of three colours, black, red, and white; there is ginger free from fibres and betal vines. The strength of vegetation and fertility of the soil is such, that wherever seed is sown, or slips planted, they always thrive. The environs of Ghergong furnish small apricots, yams, and pomegranates, but as these are wild, and not assisted by cultivation and engrafting, they are very indifferent. The principal crop of this country consists in rice and mash. Ades (a kind of pea) is very scarce, and wheat and barley are never sown." This is a favourable picture of the Kingdom, and although the revolutions and convulsions which it has since undergone, may have affected the industry of the inhabitants, the means of renewing it remain.

Elephants, wild buffaloes, hogs, and tigers, haunt the banks of the rivers, which are covered with grass and reeds so as to be impenetrable by men. It has been affirmed that there are neither horses, asses, nor camels here, though two species of the first are natives of a neighbouring territory. The other animals are unknown, but the rivers abound so plentifully with fish as to afford a copious supply to the inhabitants. A particular kind of animal, different from the common silk-worm, according to Turpin, produces silk of another texture, with which beautiful dresses, but of bad quality, are fabricated.

It is not unlikely that some external physical distinctions prevail among the natives, according as they inhabit the high or the low countries, and that their moral qualities are influenced by the same cause. Mahommed Cazim remarks, that the complexion of the mountaineers, like that of the inhabitants of all cold climates, is red and white. They are an active, hardy race, well formed, but the noses of the women are flattish. Both sexes go almost naked; formerly the mountaineers were absolutely so; and, unlike the easterns in general, none of the females, even those of the highest rank, are veiled. They wear a blue bonnet or cap, from which hogs' teeth are suspended, which is perhaps of more recent use, as the Persian just referred to says they had neither turbans, robes, drawers, nor shoes. Their most valuable ornaments, at present, are bracelets of coral or yellow amber, and sometimes tortoise shell or sea shells. They dwell in habitations constructed of wood, bamboos, and straw, and there is only an inconsiderable difference between those of the more wealthy and the poorer classes. With regard to their state of civilization, or their manners and customs, we have very little certain information applicable to the present times. Most probably the mountaineers are more barbarous than the inhabitants of the low country and the plains; and as the kingdom is di-

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vided into a number of petty States, those may be subordinate to some paramount authority; but the frequent broils of the Rajahs retard the civilization of their subjects. Mahommed Cazim, who entertained a decided aversion to the Assamese, reproaches them with indiscriminately feeding "on all kinds of food, human flesh excepted; they even eat animals that have died a natural death." He divides them into two tribes, Assamians and Cultanians; the latter excelling the former in every thing but warlike operations.

It appears that the government of this Kingdom is monarchical, and that a Sultan or Rajah rules the whole; yet, owing to the incessant contest for power, the course of succession, if it be hereditary, is disturbed, and the most potent Chief, gaining an ascendency, restores the country to peace. The government was wont to be mildly administered: in the words of Turpin, the "king was attentive to the happiness of his subjects, and employed none excepting slaves to labour in the mines. It was the only country where humanity was not crushed under the pressure of despotism." Formerly the Rajah kept a guard of six or seven thousand warlike troops, whose courage was equal to any enterprise.

The religion of these people is supposed by Mr Hamilton to be Brahminical. It is certain that they have many temples erected to their Divinities throughout their territories, although the character and description of these Divinities have never been explained. In the time of Aurengzebe, they are said to have had no settled faith; "they do not adopt any mode of worship, practised either by Heathens or Mahometans. Nor do they concur with any of the known sects which prevail amongst mankind." But it is by no means credible, that all their temples have been erected since that æra. Rafts, covered with human heads, are sometimes seen floating down the Burhampooter through Bengal, which has excited conjectures that they belonged to victims offered to their sanguinary Deities. It is not evident, however, that human sacrifices, unless the destruction of life at funereal obsequies be called such, are publicly offered up in the neighbouring Asiatic territories. This species of barbarity has been widely extended over the world; captives were slaughtered at the pile of the ancients; slaves were buried alive to serve their masters in the world to come; and even the chosen wife of her husband's affections has been doomed to destruction at the same moment that his earthly remains were consigned to oblivion. Such customs have been familiar to mankind from the earliest records of time; and, among the rest, were practised by the natives of Assam. On the decease of a Rajah, or any distinguished person, a capacious pit was prepared, where not only his own body, but many of his women and attendants, were also buried. Of the latter was a torch-bearer, together with a quantity of oil and lamps, as essential to his comfort in a future state; some of his most elegant and useful furniture, carpets and clothes, were, in like manner, included; and even elephants, together with gold and silver, formed part of the promiscuous assemblage. A strong roof, resting on thick timbers, was then constructed over the pit, and the miserable victims, not already slain, were left to perish by a lingering death.

In regard to the present state of the arts, it is to be inferred, that the Assamese are behind many nations in their vicinity: formerly they manufactured excellent silks, chiefly for home consumption; likewise they fabricated velvet, and embroidered it beautifully with flowers. Perhaps the same is continued, as also the extraction of salt from vegetable substances; and their gunpowder was reputed of the best quality. Nay, the Easterns hence ascribed the invention of this destructive substance to their ingenuity, and affirm that it passed from them to Pegu, and thence to China. Their chief exports to Bengal are gold, elephants' teeth, two kinds of lac, which was esteemed the finest in those regions,—a coarse raw silk, and coarse cotton cloths. Brandy is made from grapes, afforded by the numerous vines in Assam. Agriculture is certainly well understood; the populousness of several districts, which have attracted the attention of the Traveller, proves that there is no scarcity of subsistence; and well frequented fairs are spoken of as being held in different places. Assam contains some celebrated Temples, probably of ancient date; and their military causeways, constructed at an early period of their history, are of admirable extent and magnitude. One of these, now in a state of decay, runs from Cooch Bahar in Bengal, through Rangamatty, to the utmost extremity of the eastern limits of the kingdom, serving as a boundary of the Bootan dominions. Another, a work of immense labour, passes the capital; and the banks of the Dhekow is connected with the southern mountains by a lofty rampart, traversing the space of ten or fifteen miles. It is undoubted, that although most authors who have treated of this subject, describe these structures as military causeways only, they have served both as the means of communication among the inhabitants during the season of inundations, and as barriers to the overflowing rivers spreading still farther on the plains. Thus the great causeway, which approaches the capital, was raised to preserve the interior from the inundations of the Dehingh, while in the dry season, the river retires two miles from its base.

A great many towns and villages are scattered over the banks of the rivers of Assam, these having been peculiarly selected by the natives for their habitations; and a certain number seems to be included in a circle, under the same administration. The capital, which is called Ghergong, Kirgana, or perhaps more properly Gurgown, is situated in 25° 35′ north latitude, 93° 10′ east longitude, at a considerable distance above Rungpoor, which is sometimes called the capital, but is only the military station of Ghergong. It stands on the high banks of the river Dhekow, or Degoo, and until recent disasters had overwhelmed it, was a place of great extent. This city, Dr Wade, who resided ten years in Assam, describes to have been ten miles long by five in breadth; and we learn from other authors, that it was fortified and encircled by a fence of bamboos, enclosing villages and fields in its circuit. Like other cities of the East, each house stood separate, amidst a cultivated spot or

garden; each side of the river was lined with dwellings, and the royal palace was situated on its banks. It had four gates, constructed of earth and stone, from each of which the palace was distant four miles and a half, by which means its position was nearly in the centre, and close to the Dhekow. This palace was a spacious edifice, apparently between two and three miles in circuit, surrounded by a causeway, planted on each side by a close bamboo hedge, serving instead of a wall, and beyond them a wet ditch, always full of water. The interior contained many apartments, both for state and convenience, elegantly ornamented. Mahommed affirms it as an undoubted fact, that 3000 carpenters and 12,000 labourers were constantly occupied, during two years, in constructing the palace; but an insurrection, which took place about the year 1790, has proved almost totally destructive of it and the rest of the city. Rungpoor, situated in 25° 47′ north latitude, and 89° 5′ east longitude, stands on the opposite side of the Dhekow, with the river Numdaugh flowing on the south; a rampart, or causeway, to resist the inundations, protects it on the east; and on the west it is secured by a bridge, the only access whereby it can be approached. The circle including it contains several towns, and is about twelve miles in length, by ten in breadth. Goahautee is the capital of Lower Assam, and the residence of a Viceroy; the surrounding territory occupies a hilly country, on both sides of the Burhampooter, the hills on each side forming a spacious amphitheatre, which has been fortified equally by nature and art. The district Goahautee is divided into north and south, including several strong passes among the fortified hills. A great number of other towns might be mentioned by name; but, excepting their position, we are unacquainted with any thing regarding them. Many were greatly injured, and some totally ruined, by the distractions of the country; the cessation of which, for a few years, is now allowing them to recover from their disasters.

The history of this kingdom is involved in great obscurity, arising both from its remote situation, and from a jealousy of strangers, which has almost entirely precluded the access of Europeans; and by a singular fatality, after this difficulty had been conquered, by the admission and residence of an intelligent physician, Dr Wade, some of the most important materials collected by him were lost on being transmitted to Europe. The present race of inhabitants is said to have occupied the country during a thousand years, but not by any means in tranquillity; at least, we know that, since 1638, they have been involved in frequent contests with their neighbours. In these, however, they have, in general, been successful, for unconquerable obstacles are opposed to their enemies. "Whenever an invading army has entered their territories, the Assamese have sheltered themselves in strong posts, and have distressed the enemy by stratagems, surprises, and alarms, and by cutting off their provisions. If these means failed, they have declined a battle in the field, but have carried the peasants into the mountains, burnt the grain, and left the country desert. But when the rainy season has set in upon the advancing enemy, they have watched their opportunity to make excursions, and vent their rage; the famished invaders have either become their prisoners, or been put to death. In this manner, powerful and numerous armies have been sunk in that whirlpool of destruction, and not a soul has escaped." Such dangers were sufficient to intimidate the boldest adventurers, and we have the testimony of eye-witnesses that they are not exaggerated. About the close of the fifteenth century, Husein Shah, King of Bengal, invaded Assam, with a formidable force of cavalry, infantry, and also of boats; and, in the outset, was successful. The Rajah, unable to meet him in the plains, retired to the mountains, whither Husein could not follow him; but returning to Bengal, he left his son with a large army to keep possession of the country; the rainy season commenced, and the roads were shut up by inundations; then the Rajah descended from the mountains, intercepted the supplies of the invaders, harassed them with skirmishes, and cut off the whole in detail. Another Prince of Hindostan attempted the conquest of Assam, with an immense force of cavalry, but, says the author, who records the enterprise, they were all devoted to oblivion in that country of enchantment; and no intelligence or vestige of them remained. The Assamese, however, met with a reverse of fortune in leaving their own confines to sail down the Burhampooter, and assail the inhabitants of Bengal; for in the year 1638, they were repulsed by the troops of Shah Jehaun.

The Rajah of Assam had assumed or preserved the title of Sarjee or Swerg, which signifies celestial, and lived in great pomp and splendour in the reign of Aurengzebe, the Mogul Emperor, who died in 1707. That great Prince, desirous of extending his conquests, sent an army, under an able general, to attempt the subjugation of this Kingdom; partly, it would appear, to humble the pride of the Rajah, who was so vain-glorious as to believe that his ancestors were of divine origin, and that one of them, inclining to visit the earth, descended by a golden ladder; partly to disseminate the principles of the Mahometan faith. The army advanced victoriously, conquering all opposition, and gained possession of the capital. There the imperial general, considering himself firmly established, made many regulations for internal administration, and also proclaimed the Mahometan religion. Measures were taken for keeping the roads open, and for supplying the army with provisions; and as the season was now changing, he resolved, when the inundations subsided, to put his troops in motion to extirpate the Rajah, and those adherents who had escaped. The conquest of Assam extended to a large portion of the country, for all the villages of Decancole submitted to the invaders; and those of Ootrecole followed: Yet it is not to be inferred that this was accomplished without loss, for the panegyrist of the general describes the country as spacious, populous, and hard to be penetrated; that it abounded in dangers; that the paths and roads were beset with difficulties; and that the obstacles to conquest were more than could be expressed. The inhabitants, he says, were enterprising, well armed, and always prepared for

battle: they had lofty forts, numerously garrisoned, and plentifully provided with warlike stores; and the approach to them was opposed by thick and dangerous jungles, and broad and boisterous rivers. Under these circumstances, it was to be considered wonderful that the army had prevailed; "but the Musselman hordes experienced the comfort of fighting for their religion, and the blessings of it reverted to the sovereignty of his just and pious Majesty." But the Assamese were unsubdued: the climate proved destructive to the Moguls, and the general was obliged, first to evacuate the city, and as his troops were harassed by the natives, they were at last compelled to retreat from the country with diminished numbers.

Towards the earlier part of the eighteenth century, it is said that some of the Bramins of Bengal reached Assam, desirous of introducing their religion there, where the inhabitants still had no settled faith. Amidst their exertions for this great object, they persuaded them that it would be gratifying to their Deity, Brama, if they would use salt imported from Bengal in preference to their own, which it greatly excelled. To this the Sovereign consented, on condition that it should be monopolized by himself, and that the vessels conveying it should not penetrate beyond the frontier; and, in consequence, forty vessels, each of from 500 to 600 tons burden, have annually been sent thither.

About the year 1790, the Kingdom was in the most distracted state from a widely extended insurrection, followed by the absolute destruction of many important places; and, in the year 1793, a detachment of British troops was sent to aid the restoration of the Rajah, who seems to have been dethroned by the insurgents. This detachment gained the capital, and completely effected their object, and the Rajah was so sensible of the assistance he had derived, that he immediately concluded a commercial treaty very favourable to the British interests. It was probably on this occasion that Dr Wade visited Assam, and that Mr Wood, of the Engineers, constructed a map of a considerable portion of the country. Either this, or another, was transmitted to Britain, we have understood, to be deposited in the Advocates' Library at Edinburgh; but, after its arrival, it unfortunately never reached the place of its destination, which is much to be regretted, since the geography and history of the country are both so little known. The troops having remained some time in Assam, suffered severely from the pestilential climate, and returned to Bengal with considerable loss. (s.)

ASSAYING, taken generally, implies an examination or analysis of any substance, whose constituent parts are to be chemically determined. The term, however, more particularly relates to the ascertaining the qualities of Gold and Silver in relation to their state of purity; and in the following observations we mean to confine ourselves entirely to this object.

Importance of this Art.

In whatever point of view we consider the art of assaying these metals, it cannot fail to appear of great importance to the welfare and prosperity of the civilized world. Every one must be aware of the importance of a metallic currency agreeing in its standard fineness with the decree which establishes its circulation; and that it is an object of the greatest consequence to a nation, to have the means of ascertaining, with accuracy, the value of the coins issued by the authority of the Monarch. Since the reign of Henry the Eighth, we have had no capricious and unjustifiable changes in the standard fineness of our coins. That monarch, as Dr Henry remarks, "after he had squandered all his father's treasures, the grants he had received from Parliament, and the great sums he had derived from the dissolution of the religious houses, began to diminish his coins both in weight and fineness. This diminution at first was small, in hopes, perhaps, that it would not be perceived; but after he had got into this fatal career, he proceeded by rapid steps to the most pernicious lengths. In the thirty-sixth year of his reign, silver money of all the different kinds was coined, which had only one-half silver and the other half alloy. He did not even stop here; in the last year of his reign, he coined money that had only 4 oz. of silver and 8 oz. of alloy in the pound weight; and the nominal pound of this base money was worth only 9s. 3¾d. of our present money. He began to debase his gold coins at the same time, and proceeded by the same degrees. But it would be tedious to follow him in every step. In this degraded and debased condition Henry the Eighth left the money of his kingdom to his son and successor Edward the Sixth. This shameful debasement of the money of his kingdom, was one of the most imprudent, dishonourable, and pernicious measures of his reign; it was productive of innumerable inconveniencies and great perplexity in business of all kinds, and the restoration of it to its standard purity, was found to be a work of great difficulty." Henry's *History of Great Britain*, Vol. XII. p. 336 and 337.

To possess the art, therefore, by which such dishonourable proceedings as are just detailed, may be speedily detected, is evidently an object of the greatest utility; in as much as the debasement of the coin would require an adjustment of the relative value of commodities to the degraded standard; and the more facility that can be given to this adjustment, the less perplexity and injury will be sustained by the public.

The importance of the art of assaying will farther appear, when we consider the extent of the manufacture of plate, and ornamental articles of gold and silver; the standard value of which is determined by an assay of a few Troy grains only. The nicety and delicacy of the operation must be great, and much practical experience requisite to obtain uniformly a satisfactory result.

Description of Implements.

The principle of assaying gold and silver is very simple; it consists of two operations—the separation of the alloy from the precious metals, and the parting of these latter from each other.

Before proceeding to the detailed description of these processes, we shall describe the furnaces and implements used in the art of assaying.

Plate XXVIII. AAAA, fig. 1. is a front elevation of an assay furnace; *aa*, a view of one of the two iron

rollers on which the furnace rests, and by means of which it is moved forward or backward; *b* the ash-pit, *c c* are the ash-pit dampers, which are moved in a horizontal direction towards each other for regulating the draught of the furnace; *d* the door or opening by which the cupels and assays are introduced into the muffle; *e* a moveable funnel or chimney by which the draught of the furnace is increased.

BBBB, fig. 2. is a perpendicular section of fig. 1.; *aa* end view of the rollers; *b* the ash-pit; *c* one of the ash-pit dampers; *d* the grate; *e* the plate upon which the muffle rests, and which is covered with loom nearly one inch thick; *f* the muffle in section representing the situation of the cupels; *g* the mouth plate, and upon it are laid pieces of charcoal, which during the process are ignited, and heat the air that is allowed to pass over the surface of the cupels, and which will be more fully explained in the sequel; *h* the interior of the furnace, exhibiting the fuel.

The total height of the furnace is 2 feet $6\frac{1}{2}$ inches; from the bottom to the grate 6 inches, the grate, muffle, plate, and bed of loom with which it is covered, 3 inches; from the upper surface of the grate to the commencement of the funnel, *e* fig. 1., $21\frac{1}{2}$ inches; the funnel *e* 6 inches. The square of the furnace which receives the muffle and fuel is $11\frac{5}{8}$ inches, by 15 inches. The external sides of the furnace are made of plates of wrought-iron, and are lined with a 2 inch fire brick.

CCCC, fig. 3. is a horizontal section of the furnace over the grate, showing the width of the mouth-piece or plate of wrought iron, which is 6 inches, and the opening which receives the muffle-plate.

Fig. 4. represents the muffle or pot, which is 12 inches long, 6 inches broad inside; in the clear $6\frac{3}{4}$. In height $4\frac{1}{2}$ inside measure, and nearly $5\frac{1}{2}$ in the clear.

Fig. 5. the muffle-plate, and which is the same size as the bottom of the muffle.

Fig. 6. is a representation of the sliding door of the mouth-plate, as shown at *d* in fig. 1.

Fig. 7. a front view of the mouth-plate or piece, *d* fig. 1.

Fig. 8. representation of the mode of making, or shutting up with pieces of charcoal, the mouth of the furnace.

Fig. 9. a view of the cupel, which is generally one inch by $\frac{7}{8}$ of an inch deep.

Fig. 10. the teaser for cleaning the grate.

Fig. 11. a larger teaser, which is introduced at the top of the furnace, for keeping a complete supply of charcoal around the muffle.

Fig. 12. the tongs used for charging the assays into the cupels.

Fig. 13. represents a board of wood used as a register, and is divided into forty-five equal compartments, upon which the assays are placed previous to their being introduced into the furnace. When the operation is performed, the cupels are placed in the furnace in situations corresponding to these assays on the board; by these means all confusion is avoided, and without this regularity, it would be impossible to preserve the accuracy which the delicate operations of the assayer requires.

The furnace and implements which we have just detailed, are such as are used in the Royal Mint and Goldsmiths' Hall in the city of London.

We shall now proceed to a description of a small assay furnace invented by Messrs Anfrye and D'Arcet of Paris. They term it *le petit Fourneau a Coupelle.* Fig. 14. represents this furnace, and it is composed of a chimney or pipe of wrought-iron, *a*, and of the furnace B. It is $17\frac{1}{2}$ inches high, and $7\frac{1}{4}$ inches wide. The furnace is formed of three pieces; of a dome A; the body of the furnace B; and the ash-pit C, which is used as the base of the furnace, fig. 14. and 15. The principal piece or body of the furnace B, has the form of a hollow tower, or of a hollow cylinder, flattened equally at the two opposite sides, parallel to the axis, in such a manner, that the horizontal section is elliptical. The foot which supports it is a hollow truncated cone, flattened in like manner upon the two opposite sides, and having consequently for its basis two ellipses of different diameters; the smallest ought to be equal to that of the furnace, so that the bottom of the latter may exactly fit it. The dome, which forms an arch above the furnace, has also its base elliptical, whilst that of the superior orifice by which the smoke goes out preserves the cylindrical form. The tube of wrought-iron is 18 inches long, and $2\frac{1}{2}$ inches diameter, having one of its ends a little enlarged and slightly conical, that it may be exactly fitted or jointed upon the upper part of the furnace dome *d*, fig. 14. At the union of the conical and cylindrical part of the tube, there is placed a small gallery of iron *e*, fig. 14. 15. and 16. See also the plan of it, fig. 17. This gallery is both ingenious, useful, and necessary; upon it are placed the cupels, which are properly heated during the ordinary work of the furnace, that they may be introduced into the muffle, when it is brought into its proper degree of heat. A little above this gallery is a door *f*, by which, if thought proper, the charcoal could be introduced into the furnace; and above that there is placed at *g*, a key or valve which is used for regulating the draught of the furnace at pleasure. Messrs Anfrye and D'Arcet say, that, to give the furnace the necessary degree of heat so as to work the assays of gold, the tube must be about 18 inches high above the gallery for annealing or heating the cupels. The circular opening *h*, in the dome fig. 14., and as seen in the section fig. 15., is used to introduce the charcoal into the furnace; it is also used to inspect the interior of the furnace, and to arrange the charcoal round the muffle. This opening is kept shut during the working of the furnace, with the mouth-piece, of which the face is seen at *n*, fig. 15.

The section of the furnace fig. 15. presents several openings; the principal, which is that of the muffle, is placed in *i*; it is shut with the semicircular door *m*, fig. 14., and as seen in the section *m*, fig. 15. In front of this opening is the table or shelf, upon which the door of the muffle is made to advance or recede; the letter *q*, fig. 15., shows the face, side, and cross section of the shelf, which makes part of the furnace. Immediately under the shelf is a horizontal slit *l*, which is pierced at the level of the upper part of the grate, and used for the introduction of the rod of

iron fig. 31., that the grate may be easily kept clean. This opening is shut at pleasure by the wedge represented at *k*, fig. 14. and 15.

Upon the back of the furnace is a horizontal slit *p*, fig. 15., which supports the fire brick S, fig. 15., and upon which the end of the muffle, if necessary, may rest: *u*, fig. 15., is the opening in the furnace, where the muffle is placed.

Fig. 19. is a plan of the grate of the furnace, and fig. 20. a horizontal view of it. These two figures show us the dimensions of the ellipsis, and determines the general form of the furnace, and thickness of the grate. To give strength and solidity to the grate, it is encircled by a bar or hoop of iron. We see at *z* the groove in which the hoop of iron is fixed. The holes of the grate are truncated cones, having the greatest base below, that the ashes may more easily fall into the ash-pit. The letter V, fig. 15., shows the form of these holes. The grate is supported by a small bank or shelf, making part of the furnace, and as seen at *a*, fig. 15.

The ash-pit *c* has an opening *y* in front, fig. 15., and is shut, when necessary, by the mouth-piece *r*, fig. 14. and 15.

To give strength and solidity to the furnace, it is bound with hoops of iron at *b*, *b*, *b*, *b*, fig. 14.

Figs. 21. 22. and 23. are views of the muffle.

Fig. 24. is a view of a crucible for annealing gold.

Figs. 25. 26. and 27. are cupels of various sizes, to be used in the furnace. They are the same as those used by assayers in their ordinary furnaces.

Figs. 28. and 29. are views of the hand-shovels used for filling the furnace with charcoal; they should be made in size and form so as to fit the opening *h* in figs. 14. and 15.

Fig. 30. the smaller pincers or tongs, by which the assays are charged into the cupels, and by which the latter are withdrawn from the furnace.

Fig. 18. the teaser for cleaning the grate of the furnace.

Fig. 16. is a representation of the furnace first constructed by Messrs Anfrye and D'Arcet, and which was worked by means of a pair of bellows, which forced a current of air through the brass tube *b*, entering the ash-pit under the grate at the circular hole *c*, fig. 15. The strength of the blast or current of air can be regulated at pleasure by the stop-cock *d*, fig. 16.

Process of Assaying.

We shall now proceed to a description of the process of assaying, as performed by the assayers of the Royal Mint and Goldsmiths' Hall; and shall then state the facility afforded by the furnace of Messrs Anfrye and D'Arcet in conducting this operation upon a smaller scale and reduced expence.

Some preliminary observations may be requisite in regard to the muffle and cupels, to the proportioning of lead in assaying, &c., before the operation of the assay commences.

In the furnace above described, the number of assays that can be made at one time is 45. The same number of cupels are put into the muffle. The furnace is then filled with charcoal to the top, and upon this are laid a few pieces already ignited. In the course of three hours, a little more or less, according to circumstances, the whole is ignited; during which period the muffle, which is made of fire clay, is gradually heated to redness, and is prevented from cracking, which a less regular or more sudden increase of temperature would not fail to do. The cupels also become properly annealed; all moisture being dispelled, they are in a fit state to receive the piece of silver or gold to be assayed.

The greater care that is exercised in this operation, the less liable is the assayer to accidents from the breaking of the muffle, which it is both expensive and troublesome to fit properly into the furnace.

The cupels used in the assay process are made of the ashes of burnt bones (phosphat of lime). In the Royal Mint, the cores of oxhorn are selected for this purpose, and the ashes produced are about four times the expence of the bone ash used in the process of cupellation upon the large scale. So much depends upon the accuracy of an assay of gold or silver, where a mass of 15 lbs. Troy, in the first, and 60 lbs. Troy in the second instance, is determined by the analysis of a portion not exceeding 20 Troy grains, that every precaution which the longest experience has suggested is used to obtain an accurate result; hence the attention paid to the selection of the most proper materials for making the cupels.

The cupels are formed in a circular mould made of cast steel, very nicely turned, and by which means they are easily freed from the mould when struck. The bone ash is used moistened with a quantity of water sufficient to make the particles adhere firmly together. The circular mould is filled and pressed level with its surface; after which a pestle or rammer, having its end nicely turned, of a globular or convex shape, and its size, equal to the degree of concavity wished to be made in the cupel for the reception of the assay, is placed upon the ashes in the mould, and struck with a hammer until the cupel is properly formed. These cupels are allowed to dry in the air for some time before they are used. If the weather is dry, a fortnight will be sufficient.

The greatest possible attention should be paid to the quality of the lead used in assaying. If it contain silver, it will be easy to perceive a source of material error in the delicate operations of the assayer. Lead revived from litharge contains only about half a grain in the pound weight, and is preferred, on that account, to lead immediately revived from the ore, which usually contains a larger quantity.

The proportion of lead used in an assay of silver varies according as the external character of the silver to be assayed indicates a comparative state of fineness or coarseness to standard metal; of which an expert assayer may pretty accurately determine by the eye; but his opinion will also in some measure be regulated by the comparative ease or difficulty of flattening upon an anvil the piece of silver to be assayed;—if coarse, the metal is harder than standard, and of a brilliant glossy appearance; but, if soft and easily flattened, and of a dead white colour, it will indicate a state approaching to purity. The quantity of lead is then proportioned by the opinion of the assayer, and varies from 10 to 20 times the weight of the silver used. It should be observed, that a cupel is capable of absorbing only its own

weight of litharge, and attention should accordingly be paid to the size of the cupel, when any silver is to be assayed, which requires a great quantity of lead.

As it is always requisite to proportion the lead to the estimated quantity of alloy in the silver before cupellation, the ancient assayers made use of *touch-needles*, which were bars or slips of metal, made with pure silver, alloyed with definite proportions of copper, in a regularly increasing series, from the least to the greatest proportion, which may ever be required. The silver to be assayed was examined in comparison with the touch-needles, in colour, tenacity, and other external characters, and its alloy was estimated by that of the needle, to which it showed the closest resemblance. These needles are seldom or never used now; and the external character of the metal is sufficient to guide an experienced assayer in the proportioning of the lead, to the estimated alloy in the silver, which he has to assay.

In Aikin's *Dictionary of Chemistry and Mineralogy*, under the article ASSAYING (to which we here acknowledge our obligations), there is a table of the proportions of lead to the estimated alloy in fine silver, founded upon the experiments of Messrs Tillet, Hellot, and Macquer, which were the basis of a regulation subsequently adopted by an edict of the late French government. The great uncertainty of the use of the touch-needles, probably suggested these experiments to the French Chemists; and as this table may be extremely useful to unexperienced assayers, we shall insert it here, together with the observations accompanying it in the above work.



"Copper, the usual alloy of the fine metals, when taken singly, is found to require from ten to fourteen times its weight of lead for complete scorification on the cupel. Now, all admixtures of fine metal tend to protect the copper from the action of the litharge, and the more obstinately, the greater the proportion of fine metal. So that copper, with three times its weight of silver (or 9 oz. fine), requires forty times as much lead as copper; with eleven parts of silver it requires seventy-two parts of lead, and the like in an increasing ratio. The following is the table of the proportions of lead required to different alloys of copper; of which a few points are founded on the above mentioned experiments, and the rest filled up according to the estimated ratio of increase (being multiples of the assay integer 24 in arithmetical progression). In the three first columns is shown the absolute increase of the quantity of lead in alloys of decreasing fineness; in the three last columns will be seen the gradual diminution of the protecting power of fine metal against scorification, in proportion to the increase of alloy, shown by the decreasing quantity of lead, required for the same weight of copper, under different mixtures." (Aikin's *Dictionary.*)

TABLE.

| Silver. | Copper. | Copper. | Lead. | Ratio of Increase. | | Copper. | Silver. | Lead. |
|---|---|---|---|---|---|---|---|---|
| 23 with | 1 | requires | 96 | $= 4 \times 24$ | and hence | 1 with | 23 requires | 96 |
| 22 —— | 2 | —— | 144 | $= 6 \times 24$ | —— | 1 —— | 11 —— | 72 |
| 20 —— | 4 | —— | 192 | $= 8 \times 24$ | —— | 1 —— | 5 —— | 48 |
| 18 —— | 6 | —— | 240 | $= 10 \times 24$ | —— | 1 —— | 3 —— | 40 |
| 16 —— | 8 | —— | 288 | $= 12 \times 24$ | —— | 1 —— | 2 —— | 36 |
| 14 —— | 10 | —— | 336 | $= 14 \times 24$ | —— | 1 —— | $1\frac{2}{5}$ —— | 33 |
| 12 —— | 12 | —— | 384 | $= 16 \times 24$ | —— | 1 —— | 1 —— | 32 |
| 10 —— | 14 | —— | 432 | $= 18 \times 24$ | —— | 1 —— | $\frac{5}{7}$ —— | 30 × |
| 8 —— | 16 | —— | 480 | $= 20 \times 24$ | —— | 1 —— | $\frac{1}{2}$ —— | 30 |
| 6 —— | 18 | —— | 528 | $= 22 \times 24$ | —— | 1 —— | $\frac{1}{3}$ —— | 29 × |
| 4 —— | 20 | —— | 576 | $= 24 \times 24$ | —— | 1 —— | $\frac{1}{5}$ —— | 28 × |
| 2 —— | 22 | —— | 624 | $= 26 \times 24$ | —— | 1 —— | $\frac{1}{11}$ —— | 28 × |

In the article just referred to, it is remarked, that many assayers of good authority use proportions of lead to alloy, considerably different from the above table, and that the whole of the numbers here given may be considered as rather high in regard to the quantity of lead. The German assayers, it is added, observe the following rule:

| *Copper.* | *Silver.* | *Lead.* |
|---|---|---|
| 1 with | 30 requires | 128 |
| 1 —— | 15 —— | 96 |
| 1 —— | 7 —— | 64 |
| 1 —— | 4 —— | 56 |
| 1 —— | 3 —— | 40 |
| 1 —— | 1 —— | 30 |
| 1 —— | $\frac{1}{5}$ —— | 20 |
| 1 —— | $\frac{1}{15}$ —— | 17 |

In proportioning the lead to the alloy supposed to exist in the silver to be assayed, care must be taken not unnecessarily to increase the quantity; though it would be all oxidated or absorbed by the cupel sooner or later; which is proved by the cupellation of lead *per se*, in order to ascertain the portion of silver it contains; the latter being always found in a globular shape on the cupel, and in a state of purity.

In the process of cupellation with lead, however, there is always a loss of silver. Mr Tillet found, by experiments which he made with pure silver and lead, whose retent of silver was known, that after the process of cupellation, the button of silver was never precisely of the same weight as before; but was always a portion lighter, even when the heat of the assay furnace was not sufficient to drive off any of the silver. The conclusion was obvious,—a part of the silver was carried into the cupel by the lead;

this was proved by reviving the oxide of lead from the cupel, and cupelling the lead by itself, when the quantity of silver left upon the test was found to be ten times as great as the natural proportion of this metal in the lead, and very nearly corresponded with the loss of silver in the first instance. It will be obvious, then, that the assayer's report of the title or purity of any sample of silver (unless corrected) would make the metal somewhat less pure than it actually is, because all loss is put to the account of alloy. Mr Tillet calculates, when no more lead is used than is necessary for the entire separation of the alloy, that it carries down into the cupel as much silver as, when the whole is again reduced, would make the noble metal $\frac{1}{128}$ of the mass, when the natural admixture of the silver is only about $\frac{1}{1152}$. But if an excess of lead is employed for cupellation, this loss of silver is somewhat greater, though it does not increase in the ratio of the excess of the lead; for 10 parts of lead to a given alloy will not carry down twice as much silver as 5 parts, though the difference of loss will be very sensible.

Assay Weights.

The weights used in assaying gold and silver are peculiar to the profession. In the assaying of silver, a given number of grains are taken, which is called the *assay pound.* This assay pound varies from 14 to 24 grains Troy. This imaginary pound is subdivided into ounces and pennyweights, and the latter into half-pennyweights, which is the lowest term used in reporting assays of silver; so that there are 480 different reports for silver (this being the number of half-pennyweights in the pound); and therefore each nominal half-pennyweight weighs $\frac{1}{20}$ of a Troy grain, when the entire assay pound is 24 grains.

The report of an assay of silver is made according to the proportion of pure metal which it is found to contain. The legal standard of Sterling money of silver is 11 oz. and 2 dwts. fine, and 18 dwts. alloy. If an assay of silver was found to contain 11 oz. only of pure silver, it would be reported *worse* 2 dwts. meaning worse than standard silver by 2 dwts. or 48 grains in the pound Troy. If an assay, on the contrary, contained 11 oz. and 6 dwts. pure silver, it would be reported *better* than standard by 4 dwts. in the pound Troy; because 18 dwts. being the standard proportion of alloy, it was found that it only contained 14 dwts. alloy. When bullion thus assayed and reported is for sale, its value is calculated by reducing the bar or ingot of silver into standard metal.

| | lbs.Troy. | oz. |
|---|---|---|
| In the first example which we have given, if the ingot of silver assayed weighed | 50 | 0 |
| there would be deducted from the weight 2 dwts. per lb. or . . . . | | 5 |
| which 5 oz. is the excess of alloy above the proportion of 18 dwts. to the 11 oz. 2 dwts. of fine metal, and the bar of silver would be, in standard weight, . . | 49 | 7 |

| | lbs. | oz. |
|---|---|---|
| On the contrary, if the ingot weighed | 50 | 0 |
| and the alloy were deficient, which is the case when the metal is reported better than standard by 4 dwts. in the pound Troy, there would be added to the 50 lbs. 4 dwts. per pound, which would be equal to . . . . | 0 | 10 |
| Making the standard weight of the ingot | 50 | 10 |



The gold assay pound, which is from 10 to 20 grains Troy, is subdivided into 24 carats, and each carat into 4 assay grains, and each grain into quarters; so that there are 384 separate reports for gold, each equal to 15 Troy grains, or what is termed a quarter carat grain. An accurate assayer, however, can ascertain, in an assay of gold, to 3 grains Troy; but it is the custom of the trade not to report less than a quarter carat, or 15 grains Troy. A substantial reason is given for this rule, to justify the practice of it. An ingot of gold generally weighs a journey weight, which is 15 lbs. Troy; from a sample cut from the two opposite ends, weighing from 10 to 20 grains, the value of the mass of 15 lbs. is to be determined; if this ingot had been imperfectly melted, the mass would not be homogeneous, and a difference might exist in it of several Troy grains; and the allowance between the quarters given in the assay report is an indemnity to the purchaser. Indeed, so particular are many in the bullion trade, that they will not purchase any foreign gold bullion until it has been remelted by refiners or melters in whose integrity they repose confidence. This, we believe, is generally the case with the Bank of England, in all her purchases of foreign gold bullion.

The assay report of gold is made according as it is better or worse than standard. The standard of our gold coin is 22 carats fine, and 2 carats alloy. If, by assay, an ingot of gold was found to contain 21 carats fine gold, it would be reported *worse* 1 carat, the mass containing a carat of alloy more than the proportion of 2 carats to 22 carats fine. If the ingot weighed 15 lbs. Troy, there would be deducted from the gross weight 1 carat, or 240 grains Troy, reducing the standard of the mass to 14 lbs. 11 oz. 10 dwts. If, on the contrary, the mass was found to contain 23 carats fine gold, it would be reported 1 carat *better* than standard; and this carat would be added to the gross weight of the ingot, which we have supposed to weigh 15 lbs. Troy, and would be called 15 lbs. 0. oz. 10 dwts. of standard gold. When the gold assay pound or integer is only 12 grains, the quarter assay grain weighs only $\frac{1}{32}$ part of a Troy grain. This will show how delicate the scales must be by which the assayer works in order to obtain accuracy. In the Royal Mint, the scales of the assayers will be sensibly affected even with the $\frac{1}{1000}$th part of a Troy grain. When the Emperor of Russia lately visited the Mint, he was particularly struck with the extreme delicacy of the assay scales of Mr Bingley, the King's Assay-Master. That gentleman requested the favour of his Imperial Majesty to put one of the hairs of his head into the scale, which he did, and, to the great satisfaction of his Majesty, it very sensibly affected the equilibrium of the beam.

When the assay pound is subdivided, as for silver, in the same manner as the Troy pound, it is obvious

that all the lower denominations bear the same relation to each other; which is some little advantage in transferring the assay reports to real mixtures for use. On the contrary, the carat subdivision for gold is confined to assaying, but its fractions being aliquot parts of the pound Troy, the calculation for real use is very easy. As the pound Troy contains 5760 grains, the carat corresponds with 240 grains or 10 dwts; the assay grain, or fourth part of a carat, with 60 Troy grains; and the assay quarter-grain with 15 Troy grains; to which report, when the assayer has separated the gold (4 oz. for example), he adds 4 *oz. gold in a pound Troy*. Whereas in gold parting he takes two equal pieces, treats one as a silver assay, and the other as a gold assay, to find the absolute quantity of each metal, after which the report is made on gold singly, to which is added the report of the silver separately. Thus, if he finds 4 oz. of gold, and 3 oz. of silver, he reports *worse* 14 *carats* (2 carats being equivalent to an assay ounce, and consequently the 4 oz. of gold equal to 8 carats, which subtracted from 22 carats, the gold standard, leaves 14), to which report *he adds, fine silver 3 oz.* But when the mixed metal contains more than half alloy, it is called *metal for gold and silver*, and the absolute quantity of each reported separately. (Aikin's *Dictionary*.)

Having made the reader acquainted with these details, we shall now proceed to explain the process of assaying silver, commonly known by the name of *cupellation*.

Assay of Silver.

When we have an assay of silver to make, we flat the portion of metal upon a polished anvil; the face of the flatting hammer is also highly polished; that the metal may receive no extraneous matter whatever. The piece of metal is flatted to about the thinness of a sixpence, and an assay pound is cut from it, and most accurately weighed in such scales as we have already noticed. This assay pound is then enveloped in a sheet of lead, which is flattened from a lead bullet, and circular, but made into a funnel shape, in order to contain the silver; and the more nicely to prevent any portion of the silver from being lost, the corners of this leaden funnel are closely and firmly folded down. If the Assay-Master has 45, or, indeed, any number short of 45, they are ranged according to their number upon the table, fig. 13. When the furnace and cupels have been prepared according to the number of assays to be made, and when the proper degree of heat has been attained, the assays are charged into the cupels; and the following method is followed in this part of the process: In the first instance, a ball of lead is charged into each cupel, with the charging tongs (fig. 12.), and its weight is according to the quality of the silver to be assayed; the assayer keeping a stock of leaden bullets of different weights for the purpose. As soon as this lead is melted, which is instantaneous, the assays of silver enveloped in lead are also charged into the cupels. The mass is very soon in complete fusion. The mouth of the muffle, which had before been partially closed with cylinders of charcoal about 6 or 7 inches long, and of different diameters suitable to the convenience of the assayers, as represented in fig. 8., is now nearly closed by smaller cylinders of charcoal. The object of this precaution is, that the stream of air admitted to pass over the surface of the cupels, and which is indispensably necessary for the oxidation of the lead in the process of cupellation, may not chill the muffle, and retard the progress of the assay. The oxidation of the metal will proceed with more or less rapidity, according as the stream of air admitted is great or small, and which the assayer has it always in his power to regulate at pleasure. The work already referred to in this article, has so beautifully and accurately described the progressive appearance of the assay process of silver, that we cannot do better than quote the description: "The melted metal begins to send off dense fumes, and a minute stream of red fused matter is seen perpetually flowing from the top of the globule down its sides to the surface of the cupel, through which it sinks and is lost to view. This fume and the stream of melted matter consists of the lead oxidated by the heat and air, in one case volatilized, in the other vitrified; and in sinking through the cupel it carries down with it the copper or other alloy of the silver. In proportion to the violence of the heat, is the density of the fume, the violence with which it is given off, the convexity of the surface of the globule of melted matter, and the rapidity with which the vitrified oxide *circulates* (as it is termed), or falls down the sides of the metal. As the cupellation advances, the melted button becomes rounder, its surface becomes streaky with large bright points of the fused oxide, which moves with increased rapidity, till at last the globule, being now freed from all the lead and other alloy, suddenly *lightens*; the last portions of litharge on the surface disappear with great rapidity; showing the melted metal bright with irridescent colours, which directly after becomes opaque, and suddenly appears brilliant, clean, and white, as if a curtain had been withdrawn from it. The operation being now finished, and the silver left pure, the cupel is allowed to cool gradually, till the globule of silver is fixed, after which it is taken out of the cupel while still hot, and when cold weighed with as much accuracy as at first. The difference between the globule and the silver at first put in, shows the quantity of alloy, the globule being now perfectly pure silver, if the operation has been well performed. The reason of cooling the globule or button gradually is, that pure silver, when congealing, assumes a crystalline texture, and if the outer surface is too suddenly fixed, it forcibly contracts on the still fluid part in the centre, causing it to spurt out in arborescent shoots, by which some minute portions are often thrown out of the cupel, and the assay spoiled." (Aikin's *Dictionary*.)

Assay of Gold.

The assaying of gold, preparatory to the parting process, which we are about to describe, is exactly the same as in the case of silver; the object in the process of cupellation being to destroy the base metal or alloy contained in the gold. If gold contained only copper as alloy, the assaying of gold would be as simple and expeditious as that of silver; but all gold contains a portion of silver, which, though reckoned as alloy, cannot, as we have already seen, be destroyed

by cupellation. Recourse is had to the process, commonly called the parting process, to get rid of the silver contained in the gold. This is done by means of nitric acid, which entirely dissolves the silver, and leaves the gold perfectly pure. The quantity of silver which gold generally contains, is too small to allow the nitric acid to act upon it without addition; and the general allowance by assayers is two or three parts of silver to one of gold. If the quantity of silver greatly exceeded these proportions, the operation would not succeed so well; the fine gold would be obtained in the state of brown powder, the particles having been too minutely divided by the excess of silver.

When assays of gold have passed the test, by which all the alloy, excepting silver, has been destroyed, it is in this process that the additional quantity of silver is added. Suppose, for example, that a gold assay is made from the integer, or pound, weighing 12 grains Troy, an addition of from 24 to 36 grains of pure silver is made in addition to the small portion already supposed to exist in the mass. This becomes thoroughly incorporated with the gold in the process of cupellation. The globule, or button, as soon as it is taken from the furnace, is passed between a pair of polished steel rollers, and drawn out into a thin lamina, or plate, of the thickness of a sixpence, and returned into the furnace to be annealed. After being kept in a red heat for some time, it is taken out, and suffered to cool. It is then wound up into a cornet. This is put into a glass matrass, of the shape of an inverted cone, and with about twice or thrice its weight of very pure nitric acid. M. Vauquelin recommends it to be 1.25 specific gravity. But the true test of its strength is in the working of the process. The assayer's attention being directed to the point of strength that will maintain the gold when the silver is extracted in the spiral form, if the acid were too strong, or the silver in too great excess, the gold, as we have already mentioned, would be reduced to powder, and considerable danger exists that it would not be accurately collected, by which an imperfect result would be obtained. The glass matrass is placed upon a sand-heat, or bath, which is generally a square or oblong pan of copper, with from one to two inches of dry sand in the bottom. The pan is placed over a small square furnace, in which is burning charcoal or coke. As soon as the acid is warm, it begins to act upon the silver, and a dense stream of nitrous gas is disengaged. As long as the acid continues to act, the metal appears everywhere to be studded with very minute bubbles, which issue in jetts. The disappearance of these, or their uniting into a few large ones, is a sign or mark that the acid has ceased to act. The disappearance also of the nitrous fumes is an indication that the acid has no silver to act upon. In the course of fifteen or twenty minutes, the process is finished. But, in order to extend the last portions of silver which the mixture may contain, a small quantity of highly concentrated acid is poured upon the cornet, and boiled, by which the last portions of the silver are extracted. The cornets of gold are thoroughly corroded, but retain the same form, having lost all the silver, to two thirds or three fourths of their weight; they are slender and brittle, as we observed before. It is an object of considerable importance to prevent the cornets from being broken, the result being more likely to be accurate than having the gold in fragments; and to prevent this, the quantity of silver used is no more than is absolutely necessary, it being obvious that the less the quantity of gold, compared to the silver, used in the assay, the more likely is the gold to be broken into pieces.

The hot acid is poured very carefully from the matrass, and warm water is added to wash any remain of silver from the gold, and the addition repeated until the water comes off perfectly clear. The cornets of gold, which are of a dull brown colour, and unmetallic appearance, are then put according to their numbers into small clay crucibles, into which they are allowed gently to fall by inverting the matrass, with a portion of water in it, which breaks their fall, and also collects any grains of gold that may be in the matrass. The water is then poured off, and they are put into the furnace, and annealed under a bright cherry heat. When cooled, the pieces of gold have regained their beautiful metallic lustre, and possess all the softness and flexibility of this truly noble metal.

The pieces of gold, thus thoroughly purified, are carefully and accurately weighed, the absolute loss in weight indicating the purity of the metal assayed.

It is a matter of the greatest importance, that the silver used in this process should contain no gold, otherwise a source of very material error would arise in the delicate operations of the assayer. Silver generally contains a small portion of gold. Spanish dollars, for example, are found to contain about 4 Troy grains in the pound, and are generally preferred in the parting process upon the large scale; but assayers in general use silver revived from a precipitation of the nitrate of silver, which they are sure contains no gold.

The nitrate of silver is precipitated by immersing in it plates of copper, which throw down the silver in the metallic state. It may also be recovered by a solution of common salt, which converts the silver into luna cornea, of which, when washed and well dried, 100 parts contain 75 silver. The accuracy of the assay may also be proved by this process. The luna cornea, however, is more difficult to reduce to the metallic state, and the mode of recovery by plates of copper is always preferred.

New Process of Assaying.

It remains for us now briefly to mention the process of assaying by the *Petit Fourneau à Coupelle* of Messrs Anfrye and D'Arcey. This process is the same in principle, in all respects, as that which we have been detailing. The only difference consists in the greater facility of the process, and the comparative diminution in the fuel used. The furnace first used by these gentlemen had a small pair of bellows attached to it; see fig. 16.; and after the furnace was brought to a proper degree of heat, which required two hours and a half, the following was the result of the experiments made:

| Numérôs. | Argent Employé. | Plomb Employé. | Durée de L'Essai. | Titres. | Charbon Employé. |
|---|---|---|---|---|---|
| 1 | 1 Gram. | 4 Gram. | 12 Min. | 947 Mill. | 173 Gram. |
| 2 | .. | .. | 11 .. | 950 .. | 86 .. |
| 3 | .. | .. | 13 .. | 949 .. | 93 .. |
| 4 | .. | .. | 10 .. | 949 .. | 60 .. |
| Termes Moyens. | 1 Gram. | 4 Gram. | 11 M. 5. | 948 M. 75. | 103 Gram. |

So that each assay, on an average, was performed in $11\frac{1}{2}$ minutes, and the charcoal used did not much exceed $\frac{1}{4}$th of a pound weight. The standard of the silver used in these experiments was proved by an assay in the ordinary furnace to be 949 milliémes, and the average result by the new furnace was 948 mil. 75. a difference not more than occurs in the use of the large furnace, and an object of no importance in point of accuracy.

Experiments were also tried with this small furnace, to prove the highest degree of heat that could be produced; and two balls of Wedgwood's pyrometer were put into the furnace, which, when cold, indicated the one 35, the other 30 degrees, and is fully equal to the heat of the ordinary assay furnace.

When Messrs Anfrye and D'Arcet had improved their furnace, by adopting a tube of iron in place of the bellows, they could raise the proper degree of heat in the furnace in half-an-hour, which required by the original construction two hours and a half.

The following experiments were made upon some five franc pieces, the standard of which, according to law, should have been from 897 to 903 milimétres:

| Numérôs. | Argent Employé. | Plomb Employé. | Durée de L'Essai. | Titres. | Charbon Employé. |
|---|---|---|---|---|---|
| 1 | 1 Gram. | 7 Gram. | 15 Min. | 900 Mill. | 120 Gram. |
| 2 | 1 .. | 7 .. | 14 .. | 902 .. | 123 .. |
| 3 | 1 .. | 7 .. | 14 .. | 901 .. | 175 .. |
| Termes Moyens. | 1 Gram. | 7 Gram. | 14.33 | 901 Mill. | 139.33 qrs. |

These experiments differ very little from those we have already stated; a trifling increase in the duration of the assay, and in the charcoal consumed, being the only difference; and the greater facility which this furnace has of being raised to the necessary degree of heat, before the assays are charged into the cupels, more than compensate for the increased duration of the assay and charcoal consumed.

This small furnace is particularly recommended for the service of the *Bureaux de Garantie de Province*, where a limited number of assays are from time to time made; and, in point of economy, presents many advantages to recommend it to a place in the chemical laboratory.

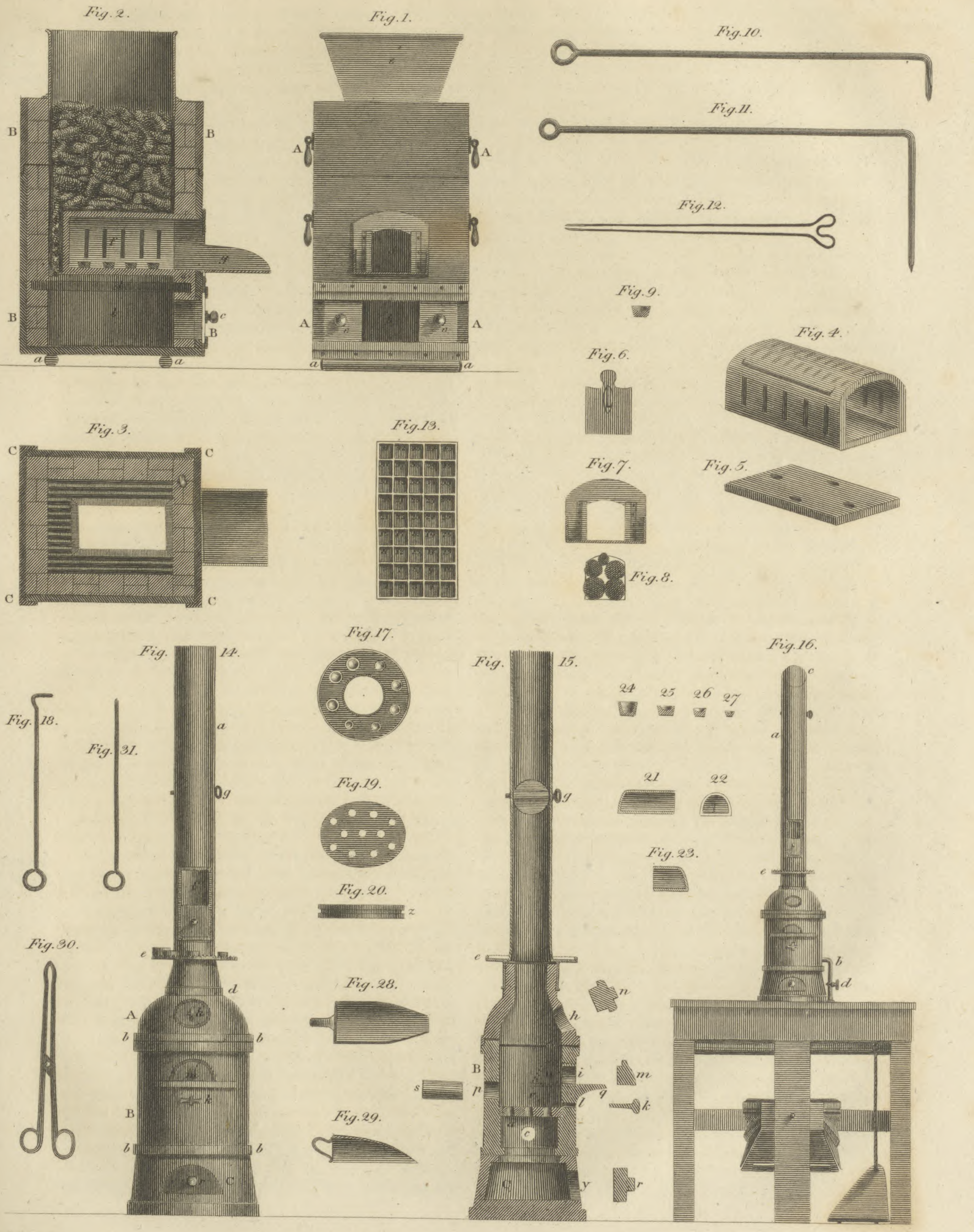
This furnace may also be used for a melting furnace; and to convert it to this purpose, the muffle is taken out, and the various apertures, which are open when the assays are making, closed by their respective stoppers: a stand may then be put upon the grate, and a crucible of such size as the furnace will admit, placed upon it, and which can very readily and conveniently be done from the opening *h*, fig. 15. In this use of the furnace, coke may be employed instead of the charcoal, the heat being greater and more steady with the former than the latter. (AA.)

ASSURANCE. See the article INSURANCE in the *Encyclopædia*. The subject of *Life Assurances*, partly treated there, requires some correction, and a more detailed explanation in this place. Assurance on lives, is the *assurance of a certain sum of money to be paid in the event of a person named being alive at a certain time, or dying within a certain time, or to be paid within a certain time after the death of a person named, whenever that may happen.* The party agreeing to pay this sum, is called the *Assurer*, and the sum he receives in compensation for what he is to pay, is called the *Premium* of assurance. The instrument by which the party is bound to pay the sum assured, is called a *Policy* of assurance. Nature of the Contract.

Policies of this kind are granted either by individuals or by companies, more generally by companies, on account of the greater security there is in large bodies of men, and which cannot easily be attained by an individual, when the policy may be of long continuance.

The policies to be paid on the death of a person or persons named, are also absolute or contingent; *absolute*, when the sum assured is payable on the death of a party assured; contingent, when the payment of this sum depends on some other event; as, for example, the existence or antecedent death of some other person or persons.

The premium of assurance is either a gross sum paid down at once, or a sum paid down on the day that the contract is made, with an obligation to pay the same sum annually, during the existence of the policy. The latter is the more general mode of assurance.




J. Farey delin.

E. Mitchell sculp.

Mode of effecting an Assurance.

As policies on lives are much more frequently conducted by companies than individuals, the mode generally adopted by those companies shall be first explained. The party desirous of effecting an assurance, receives from the office of the company a printed paper called a declaration, which he fills up with the name of the party to be assured, his age, the place and time of his birth, and place of his present residence, with certain particulars as to his health. This declaration is then duly signed; and it contains a clause, stating, that any falsehood in the declaration invalidates the policy. To corroborate the statement, references are given to two persons well acquainted with the party on whom the assurance is made, one of whom is to be a medical person, and sometimes more references are required. The reasons for these precautions are obvious.

When the declaration has been thus completed, the person by whom the assurance is made makes his appearance before the directors of the company, who inquire into the general state of his health, and a minute is entered in their books accordingly. The letter of the referrees, with the declaration, are subsequently laid before the court, which from these documents, and information frequently derived from other sources, forms its decision; and this is entered on the minutes of the court, and communicated to the applicant. A certain time is allowed for the payment of the premium; and if it is not paid within that time, the assurance cannot be effected, but by a fresh application to the court, according to the forms above mentioned. On the payment of the premium a receipt is given, containing the number of the policy, which is then made out according to the declaration, inspected by the court, signed by a certain number of directors, and delivered to the other party interested in it.

If the person, on whose life the assurance is made, cannot appear before the directors, or any one appointed by them for that purpose, an additional sum is charged for non-appearance. There is also a duty to be paid to government on each policy, and this, with a small entrance fee, makes an addition to the first year's premium. But the premium itself is only named in the policy, as on the future payment of this sum its existence depends.

Assurances are assignable.

A policy is assignable, and frequently forms a security for sums advanced, and not unfrequently becomes an object of sale. In these cases the holder of the policy pays the future premiums, and the advantage of a purchaser consists in holding a policy at a less premium than he must have paid at the present age of the party, on whose life the assurance was made. Thus, supposing a policy to have been granted for the payment of a thousand pounds, at the death of a party aged between 37 and 38, when the policy was made; suppose it is sold when the party is between 50 and 51; the purchaser will have to pay L.32, 5s. annually, during the existence of the policy: whereas, if he had taken out a policy at the present age of the party, his premium would be L. 46, 15s. For the difference between these two sums, namely L. 14, 10s., a price is fixed on; but it is to be observed, that, in the sale of a policy in the market, this disadvantage attends it,—that the bidders, not being acquainted with the person on whose life the policy is made, and being liable to trouble and expence, to ascertain that he is alive at each payment of the premium, must make a deduction on this account, from what they might otherwise presume to be a compensation for the difference between the two premiums. Policies are in consequence sold at very disproportionate prices; and it is evident, that a policy must be most valuable to the party assured himself, and less so to others, according to their convenience of paying the premiums, and receiving proper information respecting the party in whose life and death they are interested.

On the death of the party on whom the claim depends, certain documents are required, such as the register of the burial of the deceased; and references to the medical persons or others who attended him in his last illness; and, if he effected the policy himself, the probate of his will, or, if it has been assigned to another, the copy of the assignment. The grounds of these precautions are, with respect to the receiver of the sum assured, obvious; and the nature of the death must be ascertained; as, in case of suicide, or dying by the hands of justice, or on the high seas, without licence from the company, except, in general, in going from one part in the united kingdom to another, the policy is vitiated. In the interval between the notice of the party's death, and the time assigned for the payment of the claim, due investigation is made; and, every thing having been found satisfactory, the claimant brings with him the policy and a receipt for the sum claimed, which is immediately paid to him; the seals are torn from the policy, and the contract is at an end. In the case that a claim is payable, in the event of a person being alive at a certain time, his appearance before the court is requisite, or sufficient proof must be given that he was alive at the time defined by the policy.

Policies depending on a person being alive at a certain time, are very rare, and chiefly confined to endowments for children, in which case the payment of a gross sum down, or of an annual payment till the child attains the age of 21, secures to that child, at that age, the sum named in the policy. This mode of assurance has led some offices to compose a table of rates, according to which, a person at the age of 20 is required to pay a premium, which would produce at legal interest more than he would receive at the expiration of the year, from the company; and thus a person, if any such could be found, to effect an assurance of this kind, would run the risk of losing the sum assured, and receive, if successful, not so much as he could have attained without any risk at all.

Tables of Rates.

For adjusting the premium to be paid according to the age of the party on whom the assurance is made, tables of rates have been formed, and those derived from the register of mortality at Northampton are in general adopted. Tables of the duration of human life have also been made from observations in various other places; amongst which the most distinguished are those of De Parcieux, Kerseboom, Gorsuch, Aikin, and the registers of Sweden, Finland, and London. The hypothesis of De

Moivre presumes that, if eighty-six persons were born at the same time, one would die in each year till the whole number ceases to exist. This hypothesis has been abandoned, but an easy rule is derived from it, for estimating the expectation of life at any age. Subtract the age from eighty-six, and dividing the quotient by two, the remainder gives the expectation nearly. Thus, let the age be 30, then $\frac{86-30}{2}$ is 28, which differs from the Northampton table by only 27. At the age of fifty, the error is trifling, the Northampton table giving 17·99, De Moivre's, 18. But, in the higher ages, the error becomes considerable.

In the formation of these tables, a vulgar error is entertained, that they are dependant on chance; for life, being uncertain, every attempt to regulate premiums is of no avail. It is true that life cannot be reduced to a certain scale; *i. e.* if a thousand persons are named, it is impossible to state how many will die in each year, till the whole cease to exist. But though a fixed rule cannot be laid down for any given number of persons, yet an approximation may be made to the general course of life, which will sufficiently suit the purpose for which the tables are framed.

After a scale of life has been adopted, a table of premiums is derived from it by strict mathematical calculation, and in a very ingenious manner. Suppose the premium for a person of a certain age to be known; then the premium for a person of one year younger, being compounded of the premium for one year and the present value of the above premium, is easily calculated from the table of lives, thus: Multiply the premium on the oldest life into the number of persons alive in the tables at that age, and divide by the number of persons of the younger age alive in the tables. This sum, discounted for a year, gives the premium for assuring the desired sum at the end of the year. Then multiply the sum to be assured into the number of persons of the younger age, that die according to the tables in a year, and divide by the number of persons alive at that age, and this sum discounted for a year is the assurance of the sum for the first year, and consequently, the two sums added together, give the desired premium. Now, as the oldest person in the scale of life, dies in the ensuing year, the premium on him is evidently the sum to be paid discounted for one year, and thence the premium for the age below is ascertained by the above rule; and so of every age in succession. No errors can be committed without detection, as every step is checked by a similar table drawn out for the value of an annuity at each age.

In a similar manner, tables are formed for the assurance of a sum payable at the death of one out of two persons, or at the death of the survivor of two persons, or at the death of one on the contingency of his surviving another, and so on. The tables generally adopted by the companies, on the contingency of one person surviving another, being calculated by an approximation, founded on the expectation of their lives, does not partake of the mathematical accuracy of the other tables; but the companies, in this case, grant assurances at times to their own disadvantage; for if they take rather too much upon one life, they lose that sum upon the other; the premium payable on the death of one of two parties, being divided by the above-mentioned rule of approximation into two premiums, to be paid by the two parties on the contingency of one surviving the other.



The above rules give tables of rates for the payment of a gross premium: but as it is generally more convenient to pay an annual sum equivalent to it, a table of rates is made for this case, and it is formed by dividing the gross premium by the value of an annuity upon each age added to unity. If the annual premium were paid at the end of the year, the addition of unity would be unnecessary; but a policy is not granted till one premium is paid, and hence the necessity of the addition is obvious.

As premiums are settled from a fixed table of observations on life, it is evident, that, unless the deaths happen exactly in the order prescribed by the tables, there will be a surplus or deficiency of capital for the payment of the sums assured. For the latter case, a call is to be made on the proprietors to make up the deficiency: the management of the surplus or apprehended surplus, is different in different companies. Either the company appropriates the whole of the surplus to itself, or makes a compensation to the assured for it. In the former case, the company pays the sum specified in the policy, and no more. Consequently, a party may pay to the office a sum far greater than his executors or assigns receive in return. Thus, if an assurance is effected on a person aged between sixteen and seventeen for L. 100, receivable at his death, the annual premium is L. 2, 0s. 8d; and if he lives forty-nine years, he will have paid more than the whole sum to be received, without computing interest on these payments. The surplus of the accumulation of premiums above the claims, may be great from two causes: 1st, the increased interest obtained by the company above that by which the table of rates was computed; and 2d, a longer duration of life in the earlier years than is assigned by the table; and here, great circumspection on the part of the company is requisite to preserve it from imposition, and to secure the best lives that circumstances admit. In the companies where only the sum specified in the policy is paid, the surplus does not go entirely to the company; for it is common in these offices to allow a per centage on the premium to the party who brings an assurance to them, generally a solicitor, who, thus participating in the gains of the company, has an interest in increasing its concerns, though to the evident disadvantage of his client.

In companies where the surplus is made advantageous to the assured, two methods are adopted; the one is, to add, at certain periods, a sum to each policy; the other, to diminish the premium. In both cases, a valuation is made of all the annual premiums, with the past and future expected accumulations, and also of the claims upon every policy. If the former exceeds the latter to a sufficient amount, then an addition is made to each policy, or the premium is diminished. It is requisite, however, that the utmost care should be taken to secure to each policy the sum named in it, with every addition made to it; and hence a third part of the surplus is constantly retained to guard against possible contingencies. This reservation has

occasioned a singular anomaly in one of the most distinguished companies for life assurance. In that company all are partners, being mutually guarantees to each other for the payment of their respective claims. The surplus arising from the excess of premiums, with their accumulations above the claims, evidently belongs to the whole of the company, and consequently each partner is entitled to a portion of it. But of this surplus, a third being constantly reserved, and each person at his death ceasing to be a partner, every person leaves behind him a portion for his successors. This third is therefore, we may say, without an owner, for a partner has not a right to it during his life, and his heirs or assigns have not a claim upon it after his death.

This anomaly led to the formation of a plan, which is adopted by another company that vests this third in determinate hands. To do this, the company consists of a number of proprietors, each of whom is bound to keep up an assurance with it, and whose interest in these assurances is greater than that derived from the profit of assurances granted to non-proprietors. The company takes upon itself the whole risk of policies made with it, being bound to pay to each party assured the sum specified in his policy; and additions are made to each policy in the manner above-mentioned. But the third reserved is joined to, and makes part of the subscription capital stock; and the interest upon it is annually divided among the proprietors. Thus the third reserved belongs to, and continues to add to the security of the company, and the non-proprietor, secured from all risk, participates in the two thirds divisible at every period.

Another mode is adopted by a company, that prevents accumulations, by diminishing, at certain periods, the premiums paid on each assurance; and in this case the sum specified in the policy is paid, though the party assured may have paid a much less sum than in the companies above mentioned. The diminution of premium depends on the excess of capital in hand, with the present value of future premiums, above the claims that are or may be made upon it, and consequently the same care is necessary to reserve a part of the surplus for fear of future contingencies. The public have thus a choice either to receive a fixed or an increasing sum; the fixed sum by means of a definite or a probably decreasing premium, and an increasing sum by means of a definite premium. In all cases it is obvious, that it is most for the advantage of the public that the proprietors of the company should be assurers of each other, as well as of the non-proprietors.

Besides the companies for assurance in general, there are peculiar societies for a particular object,—those of clergymen, schoolmasters, officers in the army, and the like, for annuities to their widows, or sums to be paid to their assigns. In all these associations, calculations are made according to a general table of life, modified by the peculiar circumstances of the profession, which combines in assuring to each other certain advantages. In some of these, the premium annually paid remains the same, but the sum assured increases with the number of years that it has been paid. In all these societies, care should be taken to ascertain, at certain periods, the state of their concerns; and, in the formation of them this is peculiarly necessary, as the errors committed by persons unused to the calculations requisite in the particular modes of assurance, lead to very dangerous consequences.

Policies of assurance are generally confined to the limits of Europe, but they are capable of being extended to all parts of the world. In such cases, an addition is made to the premium, according to the supposed addition to the risk from unhealthiness of climate, and danger of the seas. An addition is in like manner made to the premium on account of the profession,—as of the army, in which the assured is engaged; and also an account of the diseases,—as of gout, by which he is occasionally afflicted; or of diseases,—as of small-pox and measles, to which he is liable.

Assurances granted by Individuals.

A policy granted by an individual is generally of short continuance, and the granter takes all the precautions he can to ascertain that the person is a fit subject for assurance: or, in other words, whose state of health is not worse than that of the average of persons of the same age in the tables. If the person is at a distance, a guarantee of health is required. The premiums required are generally higher than those of companies, and a policy is effected to greater amount than would be granted by a company, in consequence of the risk being divided between a number of individuals, who are only answerable for the sums assured in each name. The sum assured by policics granted by individuals, bears, however, a very small proportion to that granted by the companies.

Advantages of Life Assurances.

Assurances upon lives are of modern invention, and are very little known in foreign nations. They are suited only to those countries where property is amply secured, and public credit is fixed on a solid basis. The large capitals created by companies for assurance would be too great a temptation for the rapacity of a tyrant; and no one would be found to advance annual premiums, when his intention might be frustrated by the seizure of the whole, or a great part of his deposits. Assurances cannot be too much fostered in countries where due attention is paid to the morality, economy, and general welfare of the subject; yet, even in England, where these institutions have been raised by the people, and in a variety of ways, are of utility to the government, they have not escaped its grasp, and policies are made subject to a duty. The sum accruing to government is, in a national point of view, very trifling: but a policy being a contract, is thought a proper object for a stamp. It would, perhaps, be wiser in the nation to grant a bounty to these policies, than to make them an object of revenue.

The benefit of these institutions is far more extensive than is generally imagined. It is obvious, that persons whose incomes depend on their lives, such as clergymen, officers under government, physicians, &c. are peculiarly interested in them. By setting apart a portion of their income, they secure such a provision to their families at their death, as they

could not in any case have realised by their own exertions; and this is done with scarcely any trouble to themselves, whilst they have the confidence that, at whatever time the fatal stroke arrives, a provision is secured for those who are most dear to them. Physicians, as they rise in practice, are accustomed to increase their assurances; and facilities are given to those in inferior stations by the small sums that may be assured by each policy. A large class of persons, possessed of very considerable incomes, find their benefit in these institutions; for if their estates are entailed on their eldest sons, death may prevent them from making the provision they desire for their younger children, unless they secure it by an assurance. Persons engaged in trade have similar advantages; for, at marriage, part of the fortune of the wife, which is frequently tied up by marriage-settlements, may be realised to the husband, on appropriating a certain part of the interest of the part tied up to the payment of the premium of such a sum, as shall, with the part tied up, be equal, at his decease, to the original fortune of the wife. Short period policies are found beneficial also, in numerous instances. For example, a legacy is to be received at a certain time, if the legatee is alive at that time; it may be a few months or a few years; in either case the sum may be secured to him, for he may have it either from the office or under the will. A person takes a voyage, which will be completed within the year, and on his performance of it, depends certain advantages; these are secured in the same manner by means of the office. A debt has been contracted, which the debtor will pay at a certain time, if he is alive; the creditor secures it by assuring the life for that time. Similar cases will occur to the mind of the reader; but it is to be observed, that the legislature has very properly interfered in preventing policies being granted *ad libitum*; for otherwise they might be made the vehicles of gaming transactions. It is declared unlawful for a policy to be granted, unless the person effecting the assurance has a legal interest in the life of the party on whom it is effected, *i. e.* unless the cessation of life of that party is detrimental to him in a pecuniary way. Before the passing of the act to this purpose, persons were used to hunt out for infirm or diseased subjects, on whom to effect assurances, to the detriment of the office, or individuals they had to deal with; and even parents have effected policies on their children whose deaths, in consequence, they are said to have accelerated.

Principal Assurance Societies.

The societies for assurances on lives in London are now numerous. The oldest of them is the *Amicable Society*, instituted by charter in the year 1706. The history of this society proves the little knowledge there was on the subject at that time; for the same contribution was required from every member, whatever his age might be, and the sums received at the death of members were variable, depending on the number of persons that died in the same year. Subsequent alterations were made in this company by successive charters. At present, the several interests of the members are divided into shares, each share being now warranted to produce L. 200 at the death of the insured, together with such additions as may arise from the circumstances of the year in which the death happens; and any number of shares, and half shares, not exceeding sixty-five shares, may be granted on one and the same life, by which assurances may be effected from L. 200 to L. 5000, and participate in the benefits of the Society.

The *Royal Exchange Assurance Company* received its charter in 1720, and is chiefly engaged in insuring ships and goods at sea, and of houses and goods from fire, but it also grants annuities and assurances on life. In the latter, it confines itself to the payment of the sum assured.

The *Equitable* is the most considerable in point of numbers of the societies for the assurance of lives, to which object it is chiefly confined. In this society all are partners, and mutually assurers of each other. It arose from small beginnings, and has made considerable alterations from the rate of its first premiums, till it settled in the table annexed to this article, which is that generally adopted by these associations. At certain periods, additions have been made to the policies; and, in this manner, its affairs were conducted till December 7, 1809, when a change took place respecting the members then assured, namely, that instead of waiting till the end of the next interval, for assigning a sum out of the accumulations to each policy, every member should have two *per cent.* annually assigned to his policy, during the years of this period. Consequently, all holders of policies, prior to the year 1810, will leave to their heirs the sum assured by the policy, together with its accumulations up to the year 1810, and also two *per cent. per annum* for his life, within 1810 and 1820; but this benefit does not accrue to members entering at the close of the year 1809. Whether this plan will be continued after the year 1820, time will show. The number of the members in this society made it necessary to change some of their regulations respecting votes; and it was wisely resolved, that persons becoming members, after the 19th December 1809, should not have a vote at the general meetings, unless they had been assured for five years, for the whole continuance of life, in the sum of L. 2000; and to be a director, the qualification is an assurance of L. 5000 for the same time, and must have held it for five years.

The history of this society is very important in the subject of assurance for lives; it has been well treated by Dr Price, in his *Observations on reversionary payments*, and by Mr Morgan in his addresses to the society. In consequence of the connection of Dr Price with this institution, he drew up his remarks on the various societies which soon after sprung up, and whose names, but for his notice of them, would now be forgotten. They were formed chiefly about the years 1770 and 1771, offering very fallacious terms to the public, by which the aged were benefited at the expence of their juniors; and the evil is not yet cured; for, notwithstanding the experience of the past, similar societies are formed, but chiefly on the plan of granting annuities at the distance of ten or twelve years from a certain age, by which those at and near this age are promised such advan-

tages, as cannot be produced but by the loss of the younger part of the society.

For some time no other important society arose; but, from the year 1792, in which the *Westminster Life Assurance* was formed, several considerable companies derive their origin. The *Pelican* in 1797; the *Globe* in 1799; the *Albion* in 1805; the *Rock* and the *Provident* in 1806; the *Eagle*, *Hope*, *London Life Association*, and *Atlas*, in 1807.

The *Rock* was founded on the plan of the *Equitable;* the material distinction between them being, that the concerns of the company are vested in a body of proprietors, who are assurers of each other, and also of those who are not proprietors. Both parties, as to the additions made to the policies, are in the same situation; but, in the appropriation of the accumulations, one-third of the excess of them, above the claims, is affixed to the capital stock, these lying answerable for any claims; and the interest of it is divided among the proprietors for the risk they take among themselves in making assurances. This society confines itself entirely to assurances and annuities on life.

The *Provident* combines with life, policies on fire; but it assigns also, at certain times, additions to its policies. The *Hope* is also a fire and life office, and both are proprietary companies. The rates in these societies are the same as those in the Equitable and Rock.

The *Albion* and the *Globe* are life and fire assurance companies; their rates are also the same. They pay only the sum assured; but it is stated that "a very liberal commission is allowed to solicitors, and to others who effect life assurances."

The *London Life Association* is confined entirely to life assurances; but it differs from the others in this, that its aim is, that the benefits resulting from its transactions shall be enjoyed by the members during life; in other words, the society assures to a person the sum named in the policy and no more; but at certain times it considers, whether the surplus of the accumulations above the claims is sufficient to admit of a diminution of premium, and one is made accordingly. In this society, all are members and assurers one of the other, and consequently the surviving members at any time are bound to make up the deficiency, if any should arise by this mode of arrangement. This could be done by raising, in the first instance, the premiums that have been lowered; and it is very improbable, that, with good management, any thing farther would be necessary.

In imitation of the London Companies, several have been formed throughout the country; and it may in general be observed of them all, that where they differ from the common table of rates, it has been rather by supposing that a deduction may be made from those rates, and acting according to their discretion in this case, than by assuming a scale of life, and thence forming calculations for the premium on each age. There is some difference also in the manner in which an assurance is effected; some being supposed to be stricter in their examinations than others, and requiring greater formalities; but it must be taken into consideration, that an assurance is a contract between two parties on certain conditions, and on both sides it is desirable, that the greatest care should be taken in the formation of the contract. In fact, circumspection is the great security of both assurers and assured, for without it a society may appear to be very flourishing, when it is in fact hastening to its dissolution.

A cause in which a company out of London was lately engaged, discovered that the company at first diminished the rates, and after a time increased them, in both cases, without any regard to mathematical calculation, or a table of lives. The company refusing to pay a claim, forgot this circumstance, which was detected by the production of the two books of rates, formed at different times; and the objection to pay the claim, on the ground that the premium was not sufficient, was overruled, by comparing it with that required by the table of rates in existence when the policy was effected. Where the premium is less than that generally required, the person desirous of effecting an assurance on his life should be particularly on his guard, lest he may be a considerable sufferer by the apparent cheapness of his contract.

The following is a TABLE of the RATES generally acted upon by the Life Assurance Offices in the Capital. (BB.)

TABLE

## ASSURANCE ON SINGLE LIVES.

*To secure a Sum to the Nominee, or to the lawful Representatives of the Assured.*

| Age. | PREMIUM *per Cent* if assured from Year to Year. | | | PREMIUM *per Cent. per An.* if assured for Seven Years. | | | PREMIUM *per Cent. per An.* if assured for the whole Term of Life. | | |
|---|---|---|---|---|---|---|---|---|---|
| | *L.* | *s.* | *d.* | *L.* | *s.* | *d.* | *L.* | *s.* | *d.* |
| 8 to 14 | 0 | 17 | 9 | 1 | 1 | 5 | 1 | 17 | 7 |
| 15 | 0 | 17 | 11 | 1 | 2 | 11 | 1 | 18 | 7 |
| 16 | 0 | 19 | 2 | 1 | 4 | 7 | 1 | 19 | 8 |
| 17 | 1 | 1 | 2 | 1 | 6 | 1 | 2 | 0 | 8 |
| 18 | 1 | 3 | 3 | 1 | 7 | 5 | 2 | 1 | 8 |
| 19 | 1 | 5 | 0 | 1 | 8 | 6 | 2 | 2 | 8 |
| 20 | 1 | 7 | 3 | 1 | 9 | 5 | 2 | 3 | 7 |
| 21 | 1 | 8 | 10 | 1 | 10 | 1 | 2 | 4 | 6 |
| 22 | 1 | 9 | 3 | 1 | 10 | 6 | 2 | 5 | 4 |
| 23 | 1 | 9 | 8 | 1 | 11 | 0 | 2 | 6 | 3 |
| 24 | 1 | 10 | 2 | 1 | 11 | 6 | 2 | 7 | 1 |
| 25 | 1 | 10 | 7 | 1 | 12 | 1 | 2 | 8 | 1 |
| 26 | 1 | 11 | 1 | 1 | 12 | 7 | 2 | 9 | 1 |
| 27 | 1 | 11 | 7 | 1 | 13 | 2 | 2 | 10 | 1 |
| 28 | 1 | 12 | 1 | 1 | 13 | 9 | 2 | 11 | 1 |
| 29 | 1 | 12 | 8 | 1 | 14 | 4 | 2 | 12 | 3 |
| 30 | 1 | 13 | 3 | 1 | 14 | 11 | 2 | 13 | 5 |
| 31 | 1 | 13 | 9 | 1 | 15 | 7 | 2 | 14 | 7 |
| 32 | 1 | 14 | 4 | 1 | 16 | 3 | 2 | 15 | 9 |
| 33 | 1 | 15 | 0 | 1 | 16 | 10 | 2 | 17 | 1 |
| 34 | 1 | 15 | 8 | 1 | 17 | 8 | 2 | 18 | 5 |
| 35 | 1 | 16 | 4 | 1 | 18 | 10 | 2 | 19 | 10 |
| 36 | 1 | 17 | 0 | 1 | 19 | 7 | 3 | 1 | 4 |
| 37 | 1 | 17 | 9 | 2 | 0 | 8 | 3 | 2 | 10 |
| 38 | 1 | 18 | 6 | 2 | 1 | 9 | 3 | 4 | 6 |
| 39 | 1 | 19 | 3 | 2 | 2 | 11 | 3 | 6 | 2 |
| 40 | 2 | 0 | 8 | 2 | 4 | 1 | 3 | 7 | 11 |
| 41 | 2 | 2 | 0 | 2 | 5 | 4 | 3 | 9 | 9 |
| 42 | 2 | 3 | 6 | 2 | 6 | 6 | 3 | 11 | 8 |
| 43 | 2 | 4 | 6 | 2 | 7 | 9 | 3 | 13 | 8 |
| 44 | 2 | 5 | 6 | 2 | 9 | 2 | 3 | 15 | 9 |
| 45 | 2 | 6 | 8 | 2 | 10 | 10 | 3 | 17 | 11 |
| 46 | 2 | 7 | 10 | 2 | 12 | 6 | 4 | 0 | 2 |
| 47 | 2 | 9 | 0 | 2 | 14 | 4 | 4 | 2 | 7 |
| 48 | 2 | 10 | 3 | 2 | 16 | 4 | 4 | 5 | 1 |
| 49 | 2 | 12 | 3 | 2 | 18 | 6 | 4 | 7 | 10 |
| 50 | 2 | 15 | 1 | 3 | 0 | 8 | 4 | 10 | 8 |
| 51 | 2 | 17 | 4 | 3 | 2 | 8 | 4 | 13 | 6 |
| 52 | 2 | 19 | 1 | 3 | 4 | 9 | 4 | 16 | 5 |
| 53 | 3 | 1 | 0 | 3 | 7 | 0 | 4 | 19 | 7 |
| 54 | 3 | 3 | 0 | 3 | 9 | 5 | 5 | 2 | 10 |
| 55 | 3 | 5 | 0 | 3 | 12 | 0 | 5 | 6 | 4 |
| 56 | 3 | 7 | 3 | 3 | 14 | 8 | 5 | 10 | 1 |
| 57 | 3 | 9 | 8 | 3 | 17 | 6 | 5 | 14 | 0 |
| 58 | 3 | 12 | 3 | 4 | 0 | 6 | 5 | 18 | 2 |
| 59 | 3 | 15 | 1 | 4 | 3 | 8 | 6 | 2 | 8 |
| 60 | 3 | 18 | 1 | 4 | 7 | 1 | 6 | 7 | 4 |
| 61 | 4 | 1 | 5 | 4 | 10 | 11 | 6 | 12 | 4 |
| 62 | 4 | 3 | 11 | 4 | 15 | 0 | 6 | 17 | 9 |
| 63 | 4 | 7 | 8 | 4 | 19 | 8 | 7 | 3 | 7 |
| 64 | 4 | 10 | 9 | 5 | 4 | 10 | 7 | 9 | 10 |
| 65 | 4 | 15 | 2 | 5 | 10 | 10 | 7 | 16 | 9 |
| 66 | 5 | 0 | 1 | 5 | 17 | 7 | 8 | 4 | 1 |
| 67 | 5 | 5 | 6 | 6 | 5 | 2 | 8 | 12 | 1 |

## SURVIVORSHIP OF A LIFE ASSURED

*To secure a Sum to the Nominee or lawful Representatives of the Assured, in case a Person named shall survive another.*

| AGE of the LIFE assured. | Age of the Life against which the assurance is made. | PREMIUM *per Cent. per Annum.* | | |
|---|---|---|---|---|
| | | *L.* | *s.* | *d.* |
| 10 | 10 | 1 | 8 | 6 |
| | 20 | 1 | 9 | 1 |
| | 30 | 1 | 8 | 3 |
| | 40 | 1 | 7 | 8 |
| | 50 | 1 | 6 | 11 |
| | 60 | 1 | 6 | 0 |
| | 70 | 1 | 4 | 11 |
| | 80 | 1 | 3 | 4 |
| 20 | 10 | 1 | 16 | 6 |
| | 20 | 1 | 17 | 0 |
| | 30 | 1 | 15 | 9 |
| | 40 | 1 | 14 | 8 |
| | 50 | 1 | 13 | 6 |
| | 60 | 1 | 12 | 1 |
| | 70 | 1 | 10 | 6 |
| | 80 | 1 | 8 | 3 |
| 30 | 10 | 2 | 5 | 5 |
| | 20 | 2 | 6 | 0 |
| | 30 | 2 | 4 | 6 |
| | 40 | 2 | 2 | 9 |
| | 50 | 2 | 0 | 11 |
| | 60 | 1 | 18 | 10 |
| | 70 | 1 | 16 | 7 |
| | 80 | 1 | 13 | 9 |
| 40 | 10 | 2 | 19 | 2 |
| | 20 | 2 | 19 | 10 |
| | 30 | 2 | 18 | 2 |
| | 40 | 2 | 15 | 11 |
| | 50 | 2 | 12 | 10 |
| | 60 | 2 | 9 | 4 |
| | 70 | 2 | 5 | 11 |
| | 80 | 2 | 1 | 10 |
| 50 | 10 | 4 | 0 | 11 |
| | 20 | 4 | 1 | 10 |
| | 30 | 4 | 0 | 1 |
| | 40 | 3 | 17 | 10 |
| | 50 | 3 | 13 | 10 |
| | 60 | 3 | 7 | 7 |
| | 70 | 3 | 1 | 6 |
| | 80 | 2 | 15 | 0 |
| 60 | 10 | 5 | 16 | 9 |
| | 20 | 5 | 18 | 1 |
| | 30 | 5 | 16 | 3 |
| | 40 | 5 | 14 | 0 |
| | 50 | 5 | 10 | 7 |
| | 60 | 5 | 2 | 4 |
| | 70 | 4 | 9 | 10 |
| | 80 | 3 | 17 | 11 |
| 67 | 10 | 8 | 1 | 0 |
| | 20 | 8 | 2 | 9 |
| | 30 | 8 | 0 | 10 |
| | 40 | 7 | 18 | 7 |
| | 50 | 7 | 15 | 6 |
| | 60 | 7 | 8 | 8 |
| | 70 | 6 | 10 | 8 |
| | 80 | 5 | 8 | 9 |

## ASSURANCE ON TWO JOINT LIVES.

*To secure a Sum, payable when either of Two Persons named shall happen to die.*

| Age. | Age. | PREMIUM *per Cent. per Annum.* | | |
|---|---|---|---|---|
| | | *L.* | *s.* | *d.* |
| 10 | 10 | 2 | 17 | 1 |
| | 15 | 3 | 1 | 1 |
| | 20 | 3 | 5 | 7 |
| | 25 | 3 | 9 | 3 |
| | 30 | 3 | 13 | 9 |
| | 35 | 3 | 19 | 6 |
| | 40 | 4 | 6 | 10 |
| | 45 | 4 | 15 | 11 |
| | 50 | 5 | 7 | 10 |
| | 55 | 6 | 2 | 8 |
| | 60 | 7 | 2 | 9 |
| | 67 | 9 | 6 | 3 |
| 15 | 15 | 3 | 5 | 0 |
| | 20 | 3 | 9 | 6 |
| | 25 | 3 | 13 | 1 |
| | 30 | 3 | 17 | 6 |
| | 35 | 4 | 3 | 1 |
| | 40 | 4 | 10 | 4 |
| | 45 | 4 | 19 | 5 |
| | 50 | 5 | 11 | 3 |
| | 55 | 6 | 6 | 1 |
| | 60 | 7 | 6 | 0 |
| | 67 | 9 | 9 | 5 |
| 20 | 20 | 3 | 13 | 11 |
| | 25 | 3 | 17 | 5 |
| | 30 | 4 | 1 | 9 |
| | 35 | 4 | 7 | 3 |
| | 40 | 4 | 14 | 6 |
| | 45 | 5 | 3 | 6 |
| | 50 | 5 | 15 | 4 |
| | 55 | 6 | 10 | 2 |
| | 60 | 7 | 10 | 2 |
| | 67 | 9 | 13 | 9 |
| 25 | 25 | 4 | 0 | 10 |
| | 30 | 4 | 5 | 0 |
| | 35 | 4 | 10 | 3 |
| | 40 | 4 | 17 | 4 |
| | 45 | 5 | 6 | 2 |
| | 50 | 5 | 17 | 10 |
| | 55 | 6 | 12 | 6 |
| | 60 | 7 | 12 | 5 |
| | 67 | 9 | 15 | 9 |

| Age. | Age. | PREMIUM *per Cent. per Annum.* | | |
|---|---|---|---|---|
| | | *L.* | *s.* | *d.* |
| 30 | 30 | 4 | 8 | 11 |
| | 35 | 4 | 14 | 1 |
| | 40 | 5 | 0 | 11 |
| | 45 | 5 | 9 | 6 |
| | 50 | 6 | 1 | 0 |
| | 55 | 6 | 15 | 5 |
| | 60 | 7 | 15 | 0 |
| | 67 | 9 | 18 | 1 |
| 35 | 35 | 4 | 19 | 0 |
| | 40 | 5 | 5 | 6 |
| | 45 | 5 | 13 | 10 |
| | 50 | 6 | 5 | 0 |
| | 55 | 6 | 19 | 2 |
| | 60 | 7 | 18 | 6 |
| | 67 | 10 | 1 | 2 |
| 40 | 40 | 5 | 11 | 9 |
| | 45 | 5 | 19 | 9 |
| | 50 | 6 | 10 | 8 |
| | 55 | 7 | 4 | 5 |
| | 60 | 8 | 3 | 4 |
| | 67 | 10 | 5 | 6 |
| 45 | 45 | 6 | 7 | 4 |
| | 50 | 6 | 17 | 9 |
| | 55 | 7 | 11 | 0 |
| | 60 | 8 | 9 | 6 |
| | 67 | 10 | 11 | 1 |
| 50 | 50 | 7 | 7 | 8 |
| | 55 | 8 | 0 | 3 |
| | 60 | 8 | 18 | 2 |
| | 67 | 10 | 18 | 10 |
| 55 | 55 | 8 | 12 | 2 |
| | 60 | 9 | 9 | 0 |
| | 67 | 11 | 8 | 5 |
| 60 | 60 | 10 | 4 | 9 |
| | 67 | 12 | 2 | 1 |
| 67 | 67 | 13 | 15 | 8 |

# ASTRONOMY, PHYSICAL.

Introduction.

The whole science of Astronomy may be reduced to two general problems. The first is to express the position of all the heavenly bodies in terms of the time reckoned from a given instant, either in the past or the future duration of the world. The same may be otherwise stated by saying, that the thing required is, to express the position of any one of the heavenly bodies in a function of the time, the time being considered as the only variable quantity, though combined with other known quantities, which enter into the function as the co-efficients of the different terms. This is the most general view of that which is usually called Descriptive, or sometimes Geometrical Astronomy. The solution of this problem enables us to determine for any time the places of the heavenly bodies, relatively to one another, and relatively to any point on the earth's surface. It contains under it an endless variety of subordinate problems, embracing a long series of successive generalizations, from the first observations, to the determination of the orbits of the heavenly bodies, and the final reduction of all that concerns their motions into the form of astronomical tables. The second problem is, to compare the laws of motion in the heavens, as discovered from the preceding investigations, with the laws of motion as already known on the surface of the earth, in order to find out whether or not they are the same; and, if not, in what their difference consists. The solution of this problem constitutes what is called Physical Astronomy; it is the same with inquiring into the causes of the celestial motions: for by *causes* we mean the general facts concerning the motion of bodies which are observed to take place on the surface of the earth.

Though the first of these two problems goes necessarily before the second, for the solution of which it affords the *data*, yet, after this solution is obtained, it affords great assistance to many of the researches involved in the first, and exemplifies, in a most remarkable manner, the use of theory in the investigation of facts, and the re-action, as it were, of the second problem on the first.

Taking for granted the solution of the first problem, as given under the article ASTRONOMY in the *Encyclopædia*, we are now to consider the second, and to explain the manner in which it has been resolved by Newton and the philosophers who have come after him.

The history of the first of these two problems is long and interesting, beginning from the remotest period to which the records or the traditions of mankind have ventured to ascend, and coming down to the present time; and, in the ages to come, it is never likely to know any limit but the moveable instant which separates the past from the future,—as long, at least, as science and civilization are inhabitants of the earth.

The history of the second comes within small compass; because between the first rude effort, and the last refined investigation, there is hardly any intermediate step but one.



Introduction.

The concentric orbs of the ancient philosophers were an attempt at an explanation of the Physical causes of the Celestial Motions, or at an assimilation of those motions to such as we are accustomed to see on the surface of the earth. The great phenomenon to be explained was, the diurnal motion of the heavens, by which so many bodies, very distant from one another, all describe circles round the earth, keeping time so precisely with one another, that the revolutions, whether great or small, are accomplished in the same interval. This could not be, unless a connection subsisted between those bodies; and the most simple idea of that connection was, that the bodies were fixed in the surface of a sphere which revolved on an axis, and carried them along with it.

If the whole of Astronomy had been confined to the single fact of the diurnal revolution of the fixed stars, the hypothesis just mentioned would have been quite satisfactory. But as some of the heavenly bodies, such as the sun and planets, did not revolve precisely in the same time with the rest, it was necessary to assign to them particular spheres of their own. Those spheres therefore must be transparent; light must find an easy passage through them, and hence they must be crystalline. By degrees, as more accurate knowledge was obtained of the motion of the planets, it was found necessary so to increase the number of the spheres, that the complication of the structure was burdensome to the imagination; the hypothesis did not answer the very first object of a theory, that of connecting the facts together; and it was so unlike any process of nature with which we are acquainted, that it was highly improbable. The hypothesis of the homocentric orbs therefore fell into discredit; and, after the discovery of the earth's motion, was entirely abandoned.

The next attempt to explain the whole system of the celestial motions was that of Descartes, by means of vortices of subtle matter, and the pressure which, by the centrifugal force of those vortices, was produced on the grosser bodies of the stars. But, as a taste for accurate knowledge increased, and as men reflected more on the true objects of philosophic theory, the system of vortices appeared more and more defective, and at length ceased to have any followers.

Newton succeeded, who, rejecting all the cumbersome machinery, both solid and fluid, of his predecessors, adopted a plan far more philosophical in the design, and far more difficult in the execution, than any thing yet known in the physical or mathematical sciences. Assuming as true the three general facts concerning the planetary system known by the name of the laws of Kepler, he proceeded to inquire by what sort of action on one another the planets could be made to describe orbits having the properties indicated by these three general facts. The general facts to which we now refer, are,

I. *That every planet moves so that the line drawn from it to the sun describes about the sun areas proportional to the time.*

II. *That the planets describe ellipses, each of which has one of its foci in the same point, viz. the centre of the sun.*

III. *That the squares of the times of the revolutions of the planets are as the cubes of their mean distances from the sun.*

### Section I.

### *Of the Forces which retain the Planets in their Orbits.*

1. *If a body gravitating to a fixed centre, have a motion communicated to it in a direction not passing through that centre, it will move in a curve, and the straight line drawn from the body to the centre will describe areas proportional to the times.*

Let S (fig. 1.) be the centre to which the body A gravitates, at the same time that a motion is communicated to it in the direction AB. And first, let the gravitating or centripetal force be supposed to act not continually but at intervals, producing instantaneously, at the beginning of each interval, the same velocity that it would have produced by acting continually during the whole of that time: let AC be the space which the body would describe by the action of this force alone; also let AB be the space which it would describe in the same time by the projectile force acting on it alone. It will therefore describe the line AD, the diagonal of the parallelogram contained by AB and AC, and at the end of the first interval will be in D. If, then, no new impulse of gravity were to act on it, it would in the second interval of time go on in the direction AD, and describe DF equal to AD. But, if, at the beginning of the second interval, an impulse of the centripetal force be instantaneously impressed, sufficient to carry the body in that time from D to E, in the line DS, it will describe the line DG, the diagonal of the parallelogram contained by DE and DF. The same is true of the third interval, in which the body will go from G to L, and of every subsequent interval. Join SB, SF, SK, &c. The areas of the triangles ABS, ADS are equal, the triangles being on the same base AS, and between the same parallels AS and BD. For the same reason, the triangles DGS, DFS are equal, and DFS is equal to ADS, because they have equal bases and the same altitude. For the same reason, the triangle SGL is equal to SDG, or to ADS; and the same is true of all the other triangles that are described in the equal intervals of time by the line drawn from the body to the centre S. This holds, however short the intervals may be, and however great their number; and therefore, it is true, when the intervals are infinitely small, and their number infinitely great, that is, when the action of the centripetal force is continual.

But when the intervals of time become infinitely small, the rectilineal figure ADGL passes into a curve. For when these intervals diminish, the lines AB, DF, &c. the lengths of the parallelograms, diminish in the same proportion, but the lines AC, DE, &c. the breadths, diminish in a greater proportion, viz. in that of the squares of these intervals. Hence, the angles which AD, DG, GL, the diagonals, make with the sides AB, DF, GK, continually diminish; and therefore, the angles ADG, DGL, or the angle which each diagonal makes with that which is contiguous, increases without limit, so that, as the diagonals diminish in length, the angles they make with one another become greater than any finite rectilineal angles, and therefore the figure becomes a curve line.

That the lines AC, &c. or the supposed effect of the centrifugal force diminish as the squares of the times, is evident from the laws of the descent of heavy bodies, as explained under the head of Dynamics.

2. Hence, conversely, if a body move in a curve, so that the line drawn from it to a fixed point, describe areas proportional to the times, the body gravitates to that point, or tends continually to descend to it.

For, since it does not move in a straight line, it must be continually acted on by a deflecting force; and the direction of the deflecting force must always pass through the same point, otherwise the areas described about that point would not be proportional to the time.

3. Corollary. The velocities of a body in different points of the curve, which it describes about a centre of force, are inversely as the perpendiculars drawn from the centre to the tangents of the curve at these points. Let ACA′, fig. 2., be the curve which a body describes about the centre S. Let A$a$ and A′$a'$ be two arches of the curve, described in the same indefinitely small portion of time. Join S$a$, S$a'$, then the areas of the triangles AS$a$, A′S$a'$ are equal by this proposition. At A and A′, draw the tangents AB′ A′B′, and from S let fall on them the perpendiculars SB and SB′. Because the areas of the triangles AS$a$, A′S$a'$, are equal, $Aa \times SB = A'a' \times SB'$, or $Aa : A'a' :: SB' : SB$; but A$a$ is to A′$a'$ as the velocity of the body describing the curve at A to its velocity at A′; therefore, these velocities are inversely as the perpendiculars SB, SB′.

The straight line AB, (fig. 1.), according to which the projectile motion was impressed on the body, is a tangent to the curve at the point A.

4. On comparing the first and second of these propositions, with the first of Kepler's laws, as just enumerated, it is evident that the primary planets all gravitate to the sun, and that the secondary planets gravitate every one to its primary. The next thing, therefore, is to discover the law observed by this force, or the function of the distance to which it is proportional; and also, whether, in that function, other variable quantities are not involved beside the distance. The general fact that the orbits, or curves described by the planets round the sun are ellipses, may assist in this investigation, and in expressing the velocity of a planet, in terms of the radius vector, or its distance from the sun.

5. Let ADBE (fig. 3.) be the orbit of a planet, S the focus in which the sun is placed, AB the transverse, and DE the conjugate axis, C the centre, and F the superior focus. Let the planet be anywhere at P; draw a tangent to the orbit in P, on which from the foci let fall the perpendiculars SG, FH. Draw also DK touching the orbit in D, and let SK be perpendicular to it. Let the velocity of the planet, when at the mean distance, or at D, be $= c$, and when at

$P = v$. Join SP, FP. Then, by the corollary to the last proposition, the velocity at D is to the velocity at P as SG to SK, that is, $c : v :: SG : DC$, or $v = c . \frac{DC}{SG}$.

But because the triangles SGP, FHP, are equiangular, having right angles at G and H, and also the angles SPG, FPH equal, from the nature of the ellipse, $SP : PF :: SG : FH$, and, therefore, also $SP : PF : SG^2 : SG \times GH$. But $SG \times FH = CD^2$, therefore $SP : PF :: SG^2 : CD^2$, and $\frac{CD^2}{SG^2} = \frac{PF}{SP}$.

Now $v = c . \frac{CD}{SG}$, or $v^2 = c^2 . \frac{CD^2}{SG^2}$, and therefore $v^2 = c^2 . \frac{PF}{SP}$.

*Hence, as the distance of a planet from the sun, at any point in its orbit to its distance from the superior focus, so the square of its velocity at its mean distance from the sun to the square of its velocity at the point just mentioned.*

6. If SL be taken in the greater axis equal to SP, and $FN = PF$, so that $SN =$ the tranverse axis AB, $v^2 = c^2 . \frac{NL}{LS}$. Then as SN is a given line, $v$ is expressed in terms where SP, the distance from the sun, is the only variable quantity.

If, from the velocity of the revolving body thus expressed, in terms of the distance, a transition can be made to that of a body descending in a straight line, the law of the centripetal force will be easily investigated. This will be facilitated by the following proposition:

*An equal approach to the centre of force, produces an equal increase of the square of the velocity, whether the body revolve in a curve about the centre, or descend to it in a straight line. In like manner, equal recesses from the centre of force, produce equal diminutions of the square of the velocities, in whatever lines the bodies move.*

Let ABC (fig. 4.) be a curve which a body describes about a centre, S, to which it gravitates, while another body descends in a straight line AS, to that centre. Let BC be any arch of the curve ABC, and let BD, CH, be arches of circles described from the centre S, intersecting the line AS in D and H; the square of the velocity of the body, which describes the arch BC, will be as much increased as the square of the velocity of that which falls through DH.

From the centre S, describe the arch $bd$, indefinitely near to BD, and draw E$f$ perpendicular to the arch B$b$. Also let the centripetal force at B or D, be called G. Now, the part of this force which is in the direction B$b$, and which is employed in accelerating the body moving in that line, is $G \times \frac{Bf}{BE}$ and the increment of the space being B$b$, therefore, $2G \times \frac{Bf \times Bb}{BE}$ is the momentary increment of the square of the velocity of the body at B. But $Bf \times Bb = BE^2$, because BE$b$ is a right-angled triangle, and E$f$ the perpendicular on the hypothenuse. Therefore $2\,G \times \frac{Bf \times Bb}{BE} = 2\,G \times \frac{BE^2}{BE} = 2G \times BE = 2G \times Dd$. But $2G \times Dd$ is the momentary increment of the square of the velocity of the body at D, or the increment of that square, while the body falls from D to $d$. These momentary increments therefore are equal; and as the same may be shown for the next and every subsequent instant, the whole increase of the square of the velocities of the bodies in moving over BO and DH are equal.

If the bodies moved in the opposite directions, the one from C to B, and the other from H to O, it would be proved, in the same manner, that the squares of their velocities would be equally diminished.

7. Hence it is evident, that, if the velocities of the revolving and of the falling body, are equal in any one instance when they are equally distant from the centre, their velocities will always be equal when they are equally distant from that point. For equal quantities receiving equal increments continue equal.

8. Suppose now, that a planet revolves in the elliptical orbit APB (fig. 3.), it will have at A, the higher apsis, a velocity $= c \times \sqrt{\frac{AF}{AS}}$, or (if AN in the axis produced, be taken equal to AF) $= c \times \sqrt{\frac{AN}{AS}}$.

Let a body at A begin to descend towards S with the same velocity, then if $SL = SP$, the velocity of the planet at P, will be the same with that of the falling body at L. But the velocity of the planet at P is $c \times \sqrt{\frac{PF}{PS}} = c \times \sqrt{\frac{NL}{SL}}$, therefore, a body descending from A, and falling directly to the sun, under the action of the same centripetal force which urges the planet, would at any point L in its fall have its velocity $= c \times \sqrt{\frac{LN}{LS}}$. Hence at the point N, its velocity would be equal to 0, or the body must begin to fall from N, in order that its velocity may be everywhere equal to that which the planet has in its orbit, when at the same distance from the sun.

The law, therefore, according to which the planets gravitate is such, *that any body under the influence of the same force, and falling direct to the sun, will have its velocity at any point equal to a certain velocity, multiplied into the square-root of the distance it has fallen through, divided by the square-root of the distance between it and the sun's centre.*

This is a fact with respect to the law of gravity in the solar system, of which, though there be no direct example, yet is it no less certain than the ellipticity of the planetary orbits, of which it is a necessary consequence.

From the law thus found to regulate the velocity of bodies falling in straight lines to the sun, the law of the force by which that velocity is produced, may be derived by help of reasoning which is quite elementary.

Let C (fig. 5.) be the centre to which the falling body gravitates, A the point from which it begins to fall,

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and let its velocity at any point B, be to its velocity in the point G, which bisects AC as $\sqrt{\frac{AB}{BC}}$ to 1; it is required to find the law of the force with which the body gravitates to C.

Let DEF be a curve, such, that if AD be an ordinate or a perpendicular to AC, meeting the curve in D, and BE any other ordinate, AD is to BE, as the force at A to the force at B, then will twice the area ABED be equal to the square of the velocity which the body has acquired in B. If, therefore, the velocity at B be $v$, that at the middle point $b$ being $c$, $v = c\sqrt{\frac{AC}{BC}}$, by hypothesis, and, therefore, $2ABED = c^2 . \frac{AB}{BC}$, and since $AB = AC - BC$, $2ABED = c^2 . \frac{AC - BC}{BC} = c^2\left(\frac{AC}{BC} - 1\right)$. For the same reason $2AbED = c^2\left(\frac{AC}{bc} - 1\right)$ and, therefore, the difference of these areas, or $2BbeE$, that is, $2EB \times Bb = c^2\left(\frac{AC}{bc} - \frac{AC}{BC}\right) = c^2 . \frac{AC . Bb.}{BC^2}$ Wherefore, dividing by $Bb$, $2 EB = c^2 . \frac{AC}{BC^2}$, or $EB = c^2 . \frac{AG}{BC}$; now $c^2$ and AG are given, therefore, EB is inversely as $BC^2$, that is, the centripetal force at B is inversely as the square of BC, the distance from the centre of force. *In the planetary system, therefore, the force with which any planet gravitates to the sun, varies in the inverse ratio of the square of the distance of the planet from the sun's centre.*

10. The line CG is the same with the mean distance of the planet, in an orbit of which AC is the length of the transverse axis, and if the gravitation at that distance $= F$, and the mean distance itself $= a$, $F = c^2 . \frac{a}{a^2} = \frac{c^2}{a}$, or $aF = c^2$.

Let it next be required, the elliptic orbit of a planet being given, to find the time in which the planet will revolve round the sun.

If $a$ be the mean distance, or the semitransverse axis, $b$ the semiconjugate, then $\pi ab =$ the area of the orbit. But as $c$ is the velocity at the mean distance, or the elliptic arch which the planet moves over in a second when it is at D, the vertex of the conjugate axis, therefore $\frac{1}{2} bc$ is the area described in that second by the radius vector; and since this area is the same for every second of the planet's revolution, therefore the area of the orbit divided by $\frac{1}{2} bc$ will give the number of seconds in which the revolution is completed, which is therefore $= \frac{\pi ab}{\frac{1}{2} bc} = \frac{2\pi a}{c}$, or since $c^2 = a F$, the time of a revolution $= \frac{2\pi a}{\sqrt{aF}} = 2\pi\sqrt{\frac{a}{F}}$.

11. Hence it is easy to compare the times of the revolutions of any two planets of which the mean distances are known. Let $t$ and $t'$ be the times of revolution for two different planets, of which the mean distances are $a$ and $a'$, and the gravitation at those distances F and F′, and, by what has just been $F : F' :: a'^2 : a^2$, by what is already shown, therefore shown $t : t' :: \frac{a^{\frac{1}{2}}}{F^{\frac{1}{2}}} : \frac{a'^{\frac{1}{2}}}{F'^{\frac{1}{2}}}$, or $t^2 : t'^2 :: \frac{a}{F} : \frac{a'}{F'}$. But $t^2 : t'^2 :: \frac{a}{a'^2} : \frac{a'}{a^2}$, or $\tau^2 : \tau'^2 :: a^3 : a'^3$, *that is, the squares of the times of revolution of any two planets, are as the cubes of their mean distances from the sun.* Thus the third law of Kepler is explained by the conclusions deduced from the other two.

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12. The share which this third law has in establishing the principle of universal gravitation, does not seem to have been always clearly apprehended. From the elliptical orbit of a planet, it is fairly inferred that, over all the circumference of that orbit, gravitation is inversely as the square of the distance from the centre of the sun. That force is shown to be $\frac{c^2 a}{x^2}$, and the same is true of every individual planet; but whether $c^2 a$ was a constant quantity, or one which retained the same value through the whole planetary system, could not be known without comparing the periods of different planets, with their distances from the sun. It was indeed highly probable, that $c^2 a$ was a given quantity, or the same for every part of our system; but it could not be considered as a thing demonstrated till the evidence of the third law was introduced.

13. These laws hold of the secondary planets relatively to their primary, just as with the primary planets relatively to the sun. Each system of secondary planets, however, has a different numerator to the fraction which expresses gravity; that is, the quantity $c^2 a$ is the same for all the satellites of Jupiter, but it is a different quantity from that which belongs to the satellites of Saturn, and different from that which belongs to the primary planets. The quantity $c^2 a$ seems therefore to depend on the central body of each system of planets, and the precise nature of this connection requires to be farther examined into.

14. Let the centripetal force tending to a given centre $s$ be inversely as the squares of the distances, and let the intensity of that force at any given distance from the centre be also given; then, if a body be projected from a given point, with a given velocity, and in a given direction, it is required to determine the conic section which it will describe.

Let the semitransverse, or the mean distance to be found $= a$, the semiconjugate $= b$, the velocity at the distance $a = c$, and at the given distance $d$ let the centripetal force $= f$, and first let the direction of the initial motion be at right angles to the radius vector, so that the point of projection is either the higher or the lower apsis. Let the velocity of the projection $= v$, and the radius vector at the point of projection $= r$.

Because the areas described in equal times are

equal, $bc = rv$; and if F denote the centripetal force at the distance $a$, $c^2 = a\text{F}$, and $\text{F} = \frac{c^2}{a}$. But $\text{F} = \frac{d^2f}{a^2}$, therefore $\frac{c^2}{a} = \frac{d^2f}{a^2}$, and $c = d\sqrt{\frac{f}{a}}$. Hence, by substituting for $c$, $bd\sqrt{\frac{f}{a}} = rv$, and $b^2d^2f = ar^2v^2$. But $b^2 = \text{AS} \times \text{SB} = r\ (2\,a - r)$, wherefore $r\ (2\,a - r)\ d^2f = ar^2v^2$, and $a = \frac{rd^2f}{2d^2f - rv^2}$. Thus $a$, the semitransverse axis, and therefore the transverse axis itself is found, and thence with the focus S and the apsis A, the conic section may be described.

15. The cônic section will be a circle, when $a = r$, that is, when $2\,d^2f - v^2r = d^2f$, or when $d^2f = v^2r$, and $v^2 = \frac{d^2f}{r}$.

16. But if $2d^2f = rv^2$, or $v^2 = \frac{d^2f}{r}$, the denominator vanishes, and $r$ becomes infinite, so that the trajectory is a parabola, of which the focus is S, the vertex A, and the parameter $4r$. *The square of the velocity which determines the trajectory to be a parabola, is, therefore, double of the square of the velocity which determines it to be a circle.*

17. When $2d^2f > v^2r$, the value of $a$ is affirmative, and the conic section is an ellipsis, and this ellipsis has its higher apsis at A, if $v^2 < \frac{d^2f}{r}$, but when $v^2 > \frac{d^2f}{r}$, and less than $\frac{2d^2f}{r}$, A *is the lower apsis.*

18. When $v^2$ goes beyond this last limit, or when $v^2 > 2\,d^2f$, the value of $a$ is negative, and the trajectory become a hyperbola.

19. Next, let the body be projected from B (fig. 6.) with the velocity $v$, in the direction BD, oblique to BS. Find the distance from which a body must fall to acquire at B the velocity $v$, and let OB taken in SB produced, be equal to this distance; then is SO equal to the transverse axis. Let BE be drawn, making with BD the same angle that SB makes with BG, and let BE = BO, then is E the higher focus. Produce SE to N, so that SN = SO, and bisect EN in A, then is A the higher apsis, and if SP be made equal to EA, P is the lower apsis, and AP the transverse axis, and therefore the foci and the transverse axis being given, the elliptic orbit may be described.

20. From what has been shown at Art 9. it is evident, that the primary planets gravitate to the sun with forces that are inversely as the squares of the distances, and that the secondary gravitate toward the primary, according to the same law. This inference, however, does not apply exactly to the moon, which, being a single satellite, does not by comparison with any other, afford a proof that, in bodies revolving round the earth, the squares of the periodic times are as the cubes of the distances. The centripetal force at the moon, however, from our knowledge of her periodic time, may be compared with the force of gravity at the earth's surface, and will determine whether that force decrease as we recede from the earth in the inverse ratio of the squares of the distances.

Let $a$ be the distance of the moon from the centre of the earth, $r$ the radius of the earth, $g$ the velocity acquired by a heavy body at the earth's surface, by falling during one second; let $t$ be the period of the moon's revolution in seconds, and $c$ the velocity of her motion. Then by sect. 14. $ac^2 = r^2g$, and, therefore, $c = r\sqrt{\frac{g}{a}}$.

Now, the circumference of the circle described by the moon is $2\pi a$, and this, divided by $c$, gives the periodic time of the moon in seconds, or $\frac{2\pi a}{r} \times \sqrt{\frac{a}{g}} = t$, so that $t^2 = \frac{4\pi^2a^3}{r^2g}$, and $a^3 = \frac{r^2gt^3}{4\pi^2}$. Hence $\frac{a^3}{r^3} = \frac{gt^2}{4\pi^2r}$, and $\frac{a}{r} = \left(\frac{gt^2}{4\pi^2r}\right)^{\frac{1}{3}}$. Hence as $g$, $r$, and $t$, are known, we may find $\frac{a}{r}$ or the ratio of the moon's distance to the radius of the earth, which, if it come out the same that it is known to be, from observations of the moon's parallax, will prove, that the force which retains the moon in her orbit, is the same that causes bodies to fall at the surface of the earth, but diminished in the same ratio that the square of the moon's distance is greater than the square of the radius of the earth.

Now $g = 32.166$ feet, $r = 3481279.4$ fathoms, or $20887676.4$ feet, and $t = 2360591.5$ seconds. Hence $\frac{a}{r} = 60.218$.

Now the mean equatorial parallax of the moon is found by observation, $= 57'11''.4$ from which the mean distance in semidiameters of the equator is found $= 60.121$.

But it is in mean semidiameters of the earth, that the moon's distance is given in the former computation; therefore, to reduce the last measure to the same scale, it must be increased by a 600th part, as the mean radius of the globe is about that much less than the radius of the equator; the distance 60.121, then becomes 60.221, which agrees with the former number to the small fraction .003 of the earth's radius.

Thus, from the theory of gravity, combined with the time of the moon's sidereal revolution, her distance from the earth is found to be less than a twenty-thousandth part of the whole.

21. *It is, therefore, a general proposition, derived from the most rigorous induction, that the primary planets gravitate to the sun, and the secondary planets to the primary, with forces which are inversely as the squares of the distances.* But since, in all communication of motion, the reaction is equal to the action, when a planet gravitates to the sun, analogy forces us to conclude, that the sun gravitates to the planet, in such

a manner, that, if the momentary approach of the planet to the sun, and of the sun to the planet, were respectively multiplied by the quantity of matter in those bodies, the products, or the *quantities of motion*, would be equal. Such a mutual tendency, therefore, of the great bodies of our system to the sun, and of the sun to them, doubtless takes place; but whether this be in consequence of an attractive force residing in their centres, as the magnetic force does in certain parts of the loadstone; or if it arise from the mutual attraction of all the particles of the one for all the particles of the other, does not appear from the phenomena hitherto examined. We may, however, observe that the bodies between which this attraction in the inverse ratio of the squares of the distances takes place, are all of a round form, and are either accurately spherical, or nearly approaching to that shape. It will therefore be of use for resolving this question, to inquire whether, if the particles of matter did attract one another with forces inversely as the squares of their distances, the spherical bodies, compounded of such particles, would attract one another according to the same law. If this is found to be the case, it will be reasonable to conclude, that the gravitation of large bodies to one another arises from the mutual attraction of their particles to one another.

22. In order to determine the relation between the attraction of a sphere and that of the particles of which it consists, we may consider the sphere as made up of plates or *laminæ* infinitely great in number, and infinitely small in thickness. The attraction of each of these is to be estimated, and from thence the attraction of the whole may be computed. Let AFBG (fig. 7.) therefore, be a circular plate, of which the centre is C, CE a straight line passing through C, and perpendicular to the plane AFBG; E any particle in that line attracted by each particle of the circular plate, as D, with a force inversely as the square of DE, the distance between the particles; it is required to find the whole force with which E is attracted in the direction EC.

If DC be drawn, the force with which D attracts E in the direction ED is inversely as $DE^2$ or as $\frac{1}{DE^2}$, and that same force, reduced to the direction EC, is as $\frac{1}{DE^2} \times \frac{EC}{DE} = \frac{EC}{DE^3}$. From the centre C, with the radius DC, let a circle DKH be described, and indefinitely near it the circle $d\,k\,h$, then, since every particle in the *ring* of matter contained between these circles has its attraction proportional to $\frac{EC}{ED^3}$, the attraction of the whole ring will be as $\frac{EC}{ED^3}$ multiplied into the number of particles, or into the solidity of the ring. But if $EC = a$, $ED = x$, and $AC = r$, $CD^2 = x^2 - a^2$, and the surface of the ring $= 2\pi x\dot{x}$. If then the thickness of the plate $AFBG = m$, the solidity of the ring $= 2\pi m x\dot{x}$, and its attraction in the direction EC is $= \frac{2\pi m x\dot{x} \times a}{x^3} = \frac{2\pi a m\dot{x}}{x^2}$, the fluent of which taken so as to vanish when $DC = 0$, or when $x = a$, is $2\pi m - \frac{2\pi m a}{x} = 2\pi m\left(1 - \frac{a}{x}\right) =$ the attraction of the circle DKH. Therefore, when $x = AE$, the whole attraction of the plate, or the whole force which it exerts on the particle E, is $2\pi m\left(1 - \frac{EC}{ED}\right)$.

23. Next, let ADB (fig. 8.) be a circle of which the centre is C, and E a particle of matter any where in the diameter AB produced. Draw ED to any any point D in the circumference; draw also DC, and let DF be at right angles to AB. Then, when the whole figure revolves about EB, the semicircle ADB will generate a sphere, and DF a circle perpendicular to the plane ABD, and having its centre in F. If all the particles of the sphere attract the particle E with forces inversely as the squares of their distances from it, then, by the last proposition, the attraction of the circular plate, of which the centre is F, will be $2\pi m\left(1 - \frac{EF}{ED}\right)$.

Let $CE = a$, $AC = r$, $ED = x$, $EF = y$, and the attraction above will be $2\pi m\left(1 - \frac{y}{x}\right)$; and if $x$ and $y$ be variable, the quantity $m$ in this formula, or the thickness of the circular plate will be $= \dot{y}$, and therefore the attraction of the plate $= 2\pi\dot{y}\left(1 - \frac{y}{x}\right)$. In order to integrate this quantity, $y$ must be expressed in terms of $x$, or $x$ in terms of $y$.

Now, because $AE = a - r$, and $AF = y - a + r$, $FB = 2r - y + a - r = a + r - y$, and $AF \times FB = (y - a + r)(a + r - y) = r^2 - a^2 + 2ay - y^2 = DF^2 = x^2 - y^2$. Hence $r^2 - a^2 + 2ay = x^2$, or $y = \frac{a^2 - r^2 + x^2}{2a}$, and therefore $\dot{y} = \frac{x\dot{x}}{a}$. By substituting these values of $y$ and $\dot{y}$ in the expression for the attraction of the circular plate, that attraction

$$= \frac{2\pi x\dot{x}}{a}\left(1 - \frac{a^2 - r^2 + x}{2ax}\right)$$

$$= \pi\left(\frac{2ax\dot{x} - a^2\dot{x} + r^2\dot{x} - x^2\dot{x}}{a^2}\right).$$

But the attraction of this circular plate may be considered as the fluxion of the attraction of the spherical segment, generated by the revolution of the arch AD, and therefore the fluent of the above fluxionary quantity will give the attraction of that segment. Now, this fluent $= \pi\left(\frac{ax^2 - a^2x + r^2x - \frac{1}{3}x^3}{a^2}\right) + C.$

Here C must be so determined, that the fluent may be equal to 0, when the arch AD = 0, or when $x = y = a - r$. Therefore $C = \frac{\frac{1}{3}a^3 - ar^2 + \frac{2}{3}r^3}{a^2}$; and the attraction $= \frac{\pi}{a^2}(ax^2 - a^2x + r^2x - \frac{1}{3}x^3 + \frac{1}{3}a^3 - ar^2 + \frac{2}{3}r^3)$. This is the attraction of the spherical segment, generated by the arch AD, and will become equal to that of the whole sphere when AD = the semicircle ADB, or when $x = a + r$. This substitution being made, and the terms reduced, the attraction is found $= \frac{4\pi r^3}{3a^2}$. But $\frac{4\pi r^3}{3}$ is the solid content of the sphere; *therefore the attraction of the sphere, on any particle* E, *is as the quantity of matter in the sphere, divided by the square of the distance of its centre from* E. *Hence also the sphere attracts any particle without it, as if all its matter were united in its centre.* The sphere, it is also obvious, would attract another sphere, just in the ratio of its quantity of matter, divided by the distance of the centres of the spheres.

24. Thus, supposing that the particles of matter attract one another, with forces which are inversely as the squares of the distances, it is certain that the spherical bodies composed of these particles would do so likewise, or would attract one another with forces directly as their quantities of matter, and inversely as the squares of the distances of their centres. Since, therefore, it has been found that round or spherical bodies, such as the sun and the planets, do attract other bodies with forces that are inversely as the squares of the distances, it is reasonable to suppose, that these bodies are composed of particles gravitating towards one another, or attracting one another with forces inversely as the squares of the distances. *Gravitation, therefore, is not to be considered as a force residing in the centres of the planets, but as a force belonging to all the particles of matter, and as universally diffused throughout the universe.*

And, as it has been shown, that, between spherical bodies constituted of such particles, the force of attraction is as the quantity of matter in the attracting body, divided by the square of the distance between its centre and that of the attracted body; if $m$ be the mass or quantity of matter in the former body, and $x$ the distance of the centres, $\frac{m}{x^2}$ is the value of $f$, the accelerating force with which it attracts the other body.

25. Hence the masses of any two planets which have bodies revolving round them, may be compared with one another. Let $a$ and $a'$ be the mean distances at which satellites revolve about any two planets, $m$ and $m'$ the quantities of matter in those planets, $t$ and $t'$ their periods of revolution; it has been shown that $t = \frac{2\pi a^{\frac{3}{2}}}{f^{\frac{1}{2}}} = \frac{2\pi a^{\frac{3}{2}}}{m^{\frac{1}{2}}}$, and consequently $t : t' :: \frac{a^{\frac{3}{2}}}{m^{\frac{1}{2}}} : \frac{a'^{\frac{3}{2}}}{m'^{\frac{1}{2}}}$, and $m : m' :: \frac{a^3}{t^2} : \frac{a'^3}{t'^2}$

*The masses, therefore, of any two planets are as the cubes of the mean distances at which their satellites revolve, divided by the squares of the periodic times of those satellites.*

26. In this way, the masses of the four planets which have satellites may be compared with one another, and with the mass of the sun.

When this calculation is undertaken with the most correct data, it is found that the mass of the sun being - - - 1,

| | | |
|---|---|---|
| That of the Earth | - = | $\frac{1}{329630}$ |
| Of Jupiter | - | $\frac{1}{1067.1}$ |
| Saturn | - | $\frac{1}{3359.4}$ |
| Uranus | - | $\frac{1}{19504}$ |

Or if we make the mass of the Earth 1, that of the Sun = 329630; of Jupiter, 308.9; of Saturn, 98.122; and of Uranus, 16.94. From this also may be derived the densities of the sun, and of the four planets just mentioned. Seen from a distance equal to the mean radius of the earth's orbit, the diameter of the sun subtends an angle of 1914″; that of the earth would subtend 17″.4; of Jupiter, 186″.8; of Saturn, 177″.7; and of Uranus, 74″. The real diameters, therefore, are in the proportion of these numbers, and the bulk in the proportion of their cubes. By dividing the quantities of matter by the bulks, we have the densities; and if that of the earth be 4.713, which is its mean density, that of water being = 1.

| | | |
|---|---|---|
| The Sun | - | 1.1775 |
| The Earth | - | 4.713 |
| Jupiter | - | 1.1678 |
| Saturn | - | 0.4055 |
| Uranus | - | 1.0348 |

The mean density of the earth, in respect of water, is here taken from the experiments made at Schehallien. *Phil. Trans.* 1811, p. 376.

27. It has been already observed, that, because action is always accompanied by an equal reaction, when the sun attracts a planet, the planet also attracts the sun, and that the velocities impressed on the bodies by their mutual attraction are in the inverse ratio of their masses.

In consequence of this mutual action, the sun and the planet must both move, and must describe orbits about their common centre of gravity, the only point which the mutual action of those bodies has no tendency to put in motion.

In the solar system, therefore, the centre of gravity of the whole is the focus about which all the orbits are described. Thus if C be that centre (fig. 9.), S the sun, and P a planet, while P describes the elliptic arch PP′ about C, S describes the arch SS′ similar to PP′, and having to it the ratio that SC has to CP, or the ratio which the mass of the planet has to the mass of the sun.

The true orbits, therefore, are all described about the same immoveable point; but the orbit of any of the planets may be referred to the sun as a centre,

by supposing a body placed in that centre equal to the sum of the masses of the sun and of the planet. This is true, because the bodies appear to approach one another, or to recede from one another, with a force that is equal to the sum of the forces with which they tend towards their centre of gravity. Thus if S denote the mass of the sun, and E that of the earth, the distances from the centre being CP and CS, the orbit which each of the two bodies will appear to describe round the other, is that which would be described about an immoveable centre C, with a centripetal force $= \frac{S+P}{SP^2}$.

Thus we have arrived at the knowledge of the principle of UNIVERSAL GRAVITATION, a power which pervades all nature, extending to an unlimited distance, and determining the condition of every body in the universe, at any instant from its state in the former instant, and from the relations in which it stands to all other bodies. Whether this force can be explained upon any principle more general than itself, is yet undecided, though, from the bad success which has hitherto attended all attempts towards that object, it seems probable that such explanation is not within the reach of the human understanding. This much, however, we know with certainty, that the law of Gravity, as just announced, may be considered as a very accurate expression of all the phenomena of the planetary motions.

## SECTION II.

### *Of the Forces which disturb the Elliptic Motion of the Planets.*

1. *Of the force by which the Sun disturbs the motion of the Moon round the Earth.*

28. The motion of the moon in an elliptic orbit round the earth is disturbed by the action of the sun; the gravity of the moon to the earth is increased at the quadratures, and diminished at the syzygies, and the areas described by the radius vector, except near these four points, are never exactly proportional to the times.

Let ADBC (fig. 10.) be the orbit, nearly circular, in which the moon M revolves, in the direction CADB round the earth E. Let S be the sun, and let SE, the radius of the earth's orbit, be taken to represent the force with which the earth gravitates to the sun. Then $\frac{1}{SE^2} : \frac{1}{SM^2} :: SE : \frac{SE^3}{SM^2} =$ the force by which the sun draws the moon in the direction MS. Take $MG = \frac{SE^3}{SM^2}$, and let the parallelogram KF be described, having MG for its diagonal, and having its sides parallel to EM and ES. The force MG may be resolved into the two MF, and MK, of which MF, directed towards E, the centre of the earth, increases the gravity of the moon to the earth, and does not hinder the areas described by the radius vector from being proportional to the times.

The other force MK draws the moon in the direction of the line joining the centres of the sun and earth. It is, however, only the excess of this force above the force represented by SE, or that which draws the earth to the sun, which disturbs the relative position of the moon and earth. This is evident; for if KM were just equal to ES, no disturbance of the moon relatively to the sun could arise from it. If, then, ES be taken from MK, the difference HK is the whole force in the direction parallel to SE, by which the sun disturbs the relative position of the moon and earth. Now, if in MK, MN be taken equal to HK, and if NO be drawn perpendicular to the radius vector EM produced, the force MN may be resolved into two, MO and ON; the first, lessening the gravity of the moon to the earth, and the second, being parallel to the tangent of the moon's orbit in M, accelerates the moon's motion from C to A, retards it from A to D, and so alternately in the other two quadrants.

Thus the whole solar force directed to the centre of the earth is composed of the two parts MF and MO, which are sometimes opposed to one another, but which never affect the uniform description of the areas about E. Near the quadratures, the force MN vanishes, and the force MF, which increases the gravity of the moon to the earth, coincides with CE or DE. As the moon approaches the conjunction at A, the force MO prevails over MF, and lessens the gravity of the moon to the sun. In the opposite point of the orbit, when the moon is in opposition at B, the force with which the sun draws the moon is less than that with which the sun draws the earth, so that the effect of the solar force is to separate the moon and earth, or to increase their distance; that is, it is the same as if, conceiving the earth not to be acted on, the sun's force drew the moon in the direction from E to B. This force is negative, therefore, in respect of the force at A, and the effect in both cases is to draw the moon from the sun, in a direction perpendicular to the line of the quadratures.

29. The analytical values of these forces must be found, if a more exact estimate is to be made of their effects. Let SE, considered as constant, $= a$, EM, the radius vector of the moon's orbit, $= r$, the angle CEM $= \varphi$; the mass of the sun $= m$. The force SE then, which retains the earth in its orbit, is $\frac{m}{a^2}$, and the sun's force in the direction SM, if ML be drawn perpendicular to ES, is $\frac{m}{SM^2} = \frac{m}{SL^2 + LM^2}$ $= \frac{m}{(a - r\sin\varphi)^2 + r^2\cos^2\varphi} = \frac{m}{a^2 - 2ar\sin\varphi + r^2}$. The part of this force, which is in the direction ES or MK, is therefore $\frac{ma}{(a^2 - 2ar\sin\varphi + r^2)^{\frac{3}{2}}}$. By raising the denominator to the power $-\frac{3}{2}$, rejecting the terms which involve the higher powers of $r$, and multiplying $ma$ by those that are left, the force MK comes out $= \frac{m}{a^2}\left(1 + \frac{3r}{a}\sin\varphi\right)$ nearly. Taking away from this ES or MH $= \frac{m}{a^2}$, there remains the force $MN = \frac{m}{a^3} \times 3r\sin\varphi$.

Hence the force MO $= \frac{m}{a^3} \cdot 3r \sin \overline{\varphi^2}$; and the force NO at right angles to the radius vector $= \frac{m}{a^3} \cdot 3 \sin \varphi \times \cos \varphi = \frac{m}{a^3} \cdot \frac{3r}{2} \sin 2\varphi$. Also the force MF $= \frac{mr}{a^3}$, rejecting such terms as involve the square and higher powers of $r$. Therefore MF — MO, or the whole solar force increasing or diminishing at any point, the moon's tendency to the earth is $\frac{mr}{a^3}(1 - 3\,\overline{\sin \varphi^2})$.

30. At the quadratures where $\varphi$ vanishes, this force is $\frac{mr}{a^3}$, and is affirmative, increasing the moon's gravity to the earth. At a certain point, between the quadratures and the syzygies, when $3\,\overline{\sin \varphi^2} = 1$, or $\sin \varphi = \frac{1}{\sqrt{3}}$, that is, when $\varphi = 35^\circ.\ 15'.\ 5''$, the same force becomes equal to 0, and at this point in each quadrant, the moon's gravity to the earth is neither increased nor diminished. From these points to the conjunction and opposition, as $\sin \varphi$ increases, the quantity $1 - 3\,\overline{\sin \varphi^2}$ is negative, and the moon's gravity to the earth suffers a diminution. At the opposition and conjunction $\sin \varphi = 1$, and therefore the disturbing force is $-\frac{2mr}{a^3}$, and by this quantity the moon's gravitation is diminished.

The mean quantity of the force which is thus continually directed to, or from the centre of the earth, may also be easily computed. Since for any point in the moon's orbit, where the radius vector makes the angle $\varphi$ with the line of the quadratures, this force $= \frac{mr}{a^3}(1 - 3 \sin^2 \varphi)$; multiplying by $\dot{\varphi}$, we have $\frac{mr}{a^3}(\dot{\varphi} - 3\dot{\varphi} \sin^2 \varphi)$, the fluent of which $= \frac{mr}{a^3}(-\frac{1}{2}\varphi + \frac{3}{2} \sin \varphi \cos \varphi)$, and this, when $\varphi$ is an entire circumference or four right angles, is $\frac{mr}{a^3} \times -\frac{\pi}{2}$. This is the sum of the forces for an entire revolution, and when divided by $\pi$, gives the mean force $-\frac{mr}{2a^3}$, which being negative, shows that the solar force, on the whole, diminishes the gravitation of the moon to the earth.

*Thus it appears, that at the quadratures the gravity of the moon to the earth is increased by a quantity equal to the mass of the sun, multiplied into the radius of the moon's orbit, and divided by the cube of the sun's distance from the earth: at the syzygies it is diminished by twice this quantity; and the effect on the whole is a diminution by one half of the same quantity.*

If $\frac{mr}{a^3}$ be reduced to its numerical value, supposing the moon's gravitation to the earth to be 1, it is found $= \frac{1}{174}$ nearly. Hence the mean disturbing force of the sun is nearly $= \frac{1}{583}$ of the moon's gravity to the earth.

31. From the disturbing force of the sun arise two kinds of inequalities which affect the lunar motions. The one kind affects the form and position of the orbit of that planet, the other immediately affects the motion of the planet in the orbit. When any of these inequalities is expressed numerically, the measure it so obtained is, in the language of astronomy, called *an Equation*.

32. The line in which the plane of the moon's orbit cuts the ecliptic is called the line of the nodes, and this line is subject to change its position continually, in such a manner as to go back annually $19^\circ\ 18'\ 11''$. The way in which this effect is produced may be thus conceived. That part of the solar force which is parallel to the line joining the centres of the sun and earth, is not in the plane of the moon's orbit except when the sun itself is in that plane, or when the line of the nodes, being produced, passes through the sun. In all other cases, it is oblique to the plane of the orbit, and may be resolved into two forces, one of which is at right angles to that plane, and is directed towards the ecliptic. This force of course draws the moon continually towards the ecliptic, or produces a continual deflection of the moon from the plane of her own orbit towards that of the earth. Hence the moon meets the plane of the ecliptic sooner than it would have done if that force had not acted. At every half revolution, therefore, the point in which the earth meets the ecliptic advances in a direction contrary to that of the moon's motion, or contrary to the order of the signs. This retrograde motion is such that, in its mean quantity, it amounts to $19^\circ\ 18'\ 11''$ in a year. The manner of deducing it from the theory of gravity is explained by Newton, *Princip.* Lib. iii. Prop. 31. This motion is subject to many inequalities, depending on the changes in the quantity and direction of the solar force.

If the earth and the sun were at rest, the effect of the deflecting force just described would be to produce a retrograde motion of the line of the nodes till that line was brought to pass through the sun, and of consequence the plane of the moon's orbit to do the same, after which they would both remain in their position, there being no longer any force tending to produce a change in either. The motion of the earth carries the line of the nodes out of this position, and produces, by that means, its continual retrogradation.

33. The same force produces a small variation in

the inclination of the moon's orbit, giving it an alternate increase and decrease within very narrow limits.

34. The line of the moon's apsides, that is, the longer axis of her orbit, has also a slow angular motion round the centre of the earth, which is progressive, or in the same direction with the motions of the moon itself. To conceive the cause of this phenomenon, we may begin with supposing the moon at the lower apsis, or perigee; and, it is plain, if that planet were urged by no other force than its gravitation to the earth, that after the *radius vector* had moved over 180°, the moon would be at the higher apsis, where its motion would be at right angles to the said radius. But as the mean disturbing force in the direction of the radius vector, tends, on the whole, to diminish the gravitation of the moon to the earth, the portion of her path, described in any instant, will be less bent or deflected from the tangent, than if this disturbing force did not exist. The actual path of the moon, therefore, will be less incurvated than the elliptic orbit, that would be described under the influence of gravity alone, and will not be brought to intersect the radius vector at right angles, till this last have moved over an arch of more than 180°.

Hence, the solar force, by lessening the moon's gravity to the earth, produces a progressive motion in the apsides of the lunar orbit. If the disturbing force had increased the moon's gravity to the earth, the motion of the apsides would have been *in antecedentia*.

The precise quantity of the motion of the apsides is not however easily determined. Newton left this part of the lunar theory almost untouched, and the only investigation he has entered into having any reference to it, assigned a measure only the half of that which is known from observation to belong to it. Several years afterwards, when Clairaut attempted a more accurate investigation of the lunar inequalities than was to be obtained by the method which Newton had followed, he at first encountered the same difficulty, and found that his calculus gave the motion of the apogee only half of the real quantity. He began, therefore, to suspect that gravity does not follow so simple a law as the inverse of the squares of the distances; but one which is more complex, and such as cannot be expressed but by a formula of two terms. The second of these terms he supposed to be inversely as the fourth power of the distance, and proceeded to inquire what must be the co-efficient of that term, in order to make this new supposition represent the true motion of the apsides. In order to this, he found it necessary to carry his approximation farther than he had yet done, and to include terms which he had before neglected. When these terms were included, he found, that the co-efficient he was seeking for came out equal to 0; the necessary inference from which was, that there was no such term; and that the Newtonian law of gravity, when the approximation was carried far enough, was quite sufficient to explain the motion of the apsides. This doubt concerning the law of gravity terminated, therefore, in the confirmation of it.

35. When the doubts excited by Clairaut's first attempt were made known, and before his final solution of the difficulty was fully understood, there were several mathematicians who, still following the method of Newton, endeavoured to deduce the true motion of the moon's apsides from the theory of gravity. Among those who were most successful in this attempt, were Dom. Walmesley, and afterward Dr Matthew Stewart, Professor of Mathematics in the University of Edinburgh. In his *Mathematical and Physical Tracts*, he has demonstrated this remarkable theorem.

Let $r$ be the radius of the moon's orbit, supposing it to be a circle, and the moon to be acted on only by F, her gravity to the earth. If the mean disturbing force by which the sun diminishes the moon's gravity be $f$; then will the greatest distance to which the moon will recede from the earth be $r \times \frac{F-3f}{F-5f}$; and the cube of this distance will be to the cube of $r$, in the duplicate ratio of the angle described by the moon, from one apsis to the same apsis again, to four right angles.

Hence the angle described by the radius vector from one apsis to the same apsis, is $360° \times \left(\frac{F-3f}{F-5f}\right)^{\frac{3}{2}}$.

This proposition, which is demonstrated by Dr Stewart in the 4th of his Tracts, in a manner somewhat prolix, on account of his rigorous adherence to the manner of the ancient geometry, but in a way perfectly clear and elementary, is employed by him to deduce the mean disturbing force, from the motion of the apsides as ascertained by observation. But when the mean disturbing force is known from other phenomena, the same proposition may be employed to deduce the motion of the apsides from that force. Accordingly, if the disturbing force be taken $= \frac{1}{357.7}$, the motion of the apsides will come out $= 3° \; 1' \; 20''$ for a sideral revolution of the moon, very near the quantity actually observed.

36. Having determined the sun's mean disturbing force from the motion of the apsides, Dr Stewart proceeded to determine, from the former of these, the sun's distance from the earth. The result of a very nice investigation gave the sun's parallax $6''.9$, a quantity that is no doubt too small, and makes, of course, the sun's distance too great. It is indeed but an inconsiderable part of the sun's disturbing force into which the parallax enters as an element, and therefore any deduction founded on it must be liable to this inaccuracy, that a small error in the data will produce a great one in the result.

37. After the inequalities which are conceived as belonging to the moon's orbit, come those which directly affect the place of the moon in that orbit. The most considerable of these, after what is called the equation of the centre, arising from the elliptic figure of the lunar orbit, and independent of all disturbance, is the equation or inequality called the evection, which was discovered by the Greek astronomers. This depends on the position of the transverse axis of the moon's orbit in respect of the line of the syzygies. When that axis is in the line just mention-

ed, because the quantity by which the solar force diminishes the gravitation of the moon in the syzygies is *cæteris paribus* proportional to her distance from the earth, it is greatest when the moon is in the apogee, and least when in the perigee. In this situation of the orbit, therefore, the greatest diminution is made from the quantity of the moon's gravitation, which is already the least, and the least from that which is already the greatest, the gravitation at the perigee, and therefore the difference, is augmented, and the orbit appears to have its eccentricity increased. When the line of the apsides is in the quadratures, the contrary happens; the gravitation at the apogee is most augmented, and at the perigee least; the difference is therefore diminished, and the eccentricity of the lunar orbit seems also to be diminished. This is conformable to observation; and when the evection is accurately deduced from the theory of gravitation, it appears $= (1^{0}\ 25'\ 5''\tfrac{1}{2})\,sin\left(2(☾ - ⊙) - a\right)$ where ☾ is the mean longitude of the moon, ⊙ that of the sun, and $a$ the mean anomaly of the moon counted from the perigee.

38. The moon's variation is an inequality which was discovered by Tycho, and found to depend on the angular distance of that planet from the sun. It is derived from that part of the sun's disturbing force which is at right angles to the radius vector, and which accelerates the motion of the moon from the quadratures to the syzygies, and retarding it from the syzygies to the quadratures. The effect of this force is found, from the theory of gravity, to be represented by three terms, which, if $\triangle$ be the angular distance of the moon from the sun, are,

$$+ (35'\ 47'')\ sin\ 2\ \triangle$$
$$+ (\ 0'\ 2'')\ sin\ 3\ \triangle$$
$$+ (\ 0'\ 14'')\ sin\ 4\ \triangle.$$

39. The lunar inequality, called the annual equation, arises from the variation of the sun's disturbing force according to the place which the earth occupies in its orbit. It is shown above that the sun's disturbing force is *cæteris paribus* as the cube of his distance from the earth, so that, when the earth is in its perihelion, this force is the greatest, and at the aphelion the least, its effect varying at the same rate with the equation of the sun's centre, or having everywhere the same ratio to that equation. Hence this equation is nearly $(11'\ 12'') \times sin$ sun's mean anomaly, with a contrary sign to the equation of the sun's centre.

40. These inequalities are all phenomena which were observed before the explanation of them was known. To them may be added a fourth inequality, known by the name of the moon's acceleration. It appeared to Astronomers as a continual increase in the velocity of the moon, or in the rate of her mean motion, amounting to about 10″ in a century; and its effect, like that of all other constant accelerations, accumulating as the squares of the times. It did not seem to be periodical, like the other lunar inequalities, but to be a constant increase of the velocity, and a corresponding diminution of the periodical time of the moon, which must in the end change entirely the relation of that body to the earth.

It is but within these few years that La Place discovered it to be a periodic inequality, though requiring, in order to accomplish the series of its changes, a length of time which science has not yet ventured to calculate. For many centuries to come it may be expressed by this formula, taking $n$ to denote the number of centuries reckoned from the year 1700, viz.

$$10''.1816127 \times n^2 + 0.018538441 \times n^3.$$

The first term includes all that was known from observation previously to the discovery of *La Place*. This, however, must be considered not as the true form of the equation, which must include the sines or cosines of certain angles, but merely a provisional formula, to serve till the true one can be rigorously assigned.

This inequality has, in its cause, a great affinity to the annual equation.

Whatever changes the form of the earth's orbit has an effect on the disturbing force of that body on the moon, which is in the inverse ratio of the cube of the distance between the sun and earth. But it is found that though the mean distance remains invariable, the eccentricity of the earth's orbit changes, on account of the action of the other planets, and in fact has been diminishing, from a more remote antiquity than that to which the history of astronomy extends. From this cause La Place has deduced the supposed acceleration of the moon's mean motion.

41. All these inequalities have been pointed out by observations, and have been explained in the most satisfactory manner by the principle of universal gravitation. But when all these were reduced into equations and arranged in tables, yet the places of the moon calculated from them were never quite exact; and there seemed a cause of error or a mass of small inequalities unknown in their magnitude and form, to which this inaccuracy was to be ascribed, and which operated, as it may be said, like a mist which concealed the true place of the moon from the calculator, and prevented his results from agreeing completely with those of the observer. The most likely way to discover these inequalities, if they arose from gravity, was to push the approximation to the moon's place still farther, and to try if the terms hitherto neglected in the approximation would not, when taken into account, afford a complete analysis of the circle of confusion, which might be said to surround the moon on all occasions.

The problem on which mathematicians now entered, and which Clairaut, already mentioned, Euler, and D'Alembert, all three resolved nearly about the same time, has been called the *Problem of Three Bodies*. The thing proposed is, Three bodies which attract one another with forces directly as their quantities of matter, and inversely as the squares of their distances, being given, and any motions whatever being impressed on them, to find the orbits which they will describe round their common centre of gravity. It is, however, only in certain cases, that this general problem admits of solution, and one of these is, when one of the bodies is at a vast distance from the other two. This is exactly the case with the moon and earth in respect of the sun, the orbit of the earth being nearly the same

as if there only existed the sun and earth; and the orbit of the moon relatively to the earth being nearly the same as if there were only the moon and earth. This solution of the problem, however, in this direct way, leads to far more exact conclusions than can be obtained from the more simple but more indirect method which Newton followed. The general view which leads to the most exact estimate of the merit of the two solutions, is, that the motions of the moon, when analytically and fully expressed, necessarily form a number of different series, each of which converges with more or less rapidity. The prosecution of the direct method, allows the terms of these series to be computed to an indefinite extent, or till the quantities omitted are too small to affect observation. The method of Newton can go no farther than to compute the first, or at most a few of the leading terms of each of the series. Its accuracy is therefore limited; that of the other knows no limits. Though this be a true estimate of the value of the methods, yet that of the original inventor possesses infinite merit, as having first led the way to this arduous investigation, and as still serving to carry the imagination better along with it than the other, and to keep the mechanical principles more directly in view.

The complete solution of the problem of the *three bodies*, has accordingly discovered a great number of new equations, each individually small, which would sometimes nearly destroy one another, and, at other times, having many of them the same sign, would accumulate to a considerable amount. This was the triumph of the theory, and the strongest evidence of its truth. The effect of these irregularities varied so much, and depended on so many elements, that it may be doubted whether the most accurate and most constant observation would ever have enabled astronomers to discover their precise quantities, and to separate them from one another.

The tables of the moon in the state to which they are now (1816) brought, contain twenty-eight equations for the longitude, twelve for the latitude, and thirteen for the horizontal parallax of the moon. Of the first of these, twenty-three have been deduced from theory alone; of the second nine, and of the third eleven. This applies to the tables of De Bürgh; those since published by Burckhardt contain more equations, and are still more accurate.

### 2. *Of the Disturbance in the Motion of the Primary Planets, produced by their action on one another.*

42. It is evidently necessary, in this inquiry, to know the quantities of matter in the different planets, or which comes to the same, the intensity of the attraction of each at a given distance from its centre. With respect to those planets which have satellites, the Earth, Jupiter, Saturn, and Uranus, their masses or quantities of matter have been already determined. The masses of Venus and Mars have been estimated by M. La Place, from the effects which they appear to produce on the earth's motion. The mass of Mercury has been estimated on the supposition that the densities of that planet and of the earth are inversely as their mean distances from the sun. This law holds with respect to the Earth, Jupiter, and Saturn, and analogy renders it probable that the same law includes the other planets. Thus, the mass of the Sun being 1, that of Mercury is $\frac{1}{2025810}$, of Venus $\frac{1}{383137}$, and of Mars $\frac{1}{1846082}$, the masses of the other planets being as already stated.

43. The effects of the action of the planets on one another is more difficult to be investigated than the effects of the sun's action on the moon, because the disturbing forces are not only more numerous, but because the distance of the disturbing from the disturbed body, is not so great that the quantities divided by higher powers of that distance, can be so safely rejected. The general principle, however, according to which the solar action on the moon was resolved into forces either in the direction of the radius vector, or at right angles to it, is applicable to both questions.

Thus supposing P and P′ (fig. 11.) to be two planets revolving in orbits, nearly circular, about the sun at S, in order to find how the motion of P′ is affected by the action of P, let PP′, PS, and P′S be drawn, and let the line A denote the force with which P attracts a particle of matter at the distance PS, then the force with which it attracts a particle at the distance PP′, will be $A \times \frac{PS^2}{P'P^2}$. Let P′R= $A \times \frac{PS^2}{P'P^2}$, and if P′R be resolved into two forces, P′M and P′N, the one in the direction of the radius vector P′S, and the other parallel to PS; take NO= A, then the remaining forces OP′ and P′M are those which disturb the motion of P′, as was proved in the case of the moon. The former of these, OP′, may be resolved into OQ and P′Q, of which P′Q diminishes the gravity of the planet to the sun, and OQ accelerates its motion in a direction perpendicular to the *radius vector*. Therefore, as the force P′M always increases the planet's gravity to the sun, P′M—P′Q is the whole force increasing or diminishing the gravity of P′ to S; and the force directly employed in increasing or diminishing the angular motion of P about S, is OQ or P′T. The analytical values of these quantities may be found, as in the theory of the moon, though not with equal simplicity, because SP cannot always be supposed great in respect of SP′.

44. In consequence of these actions, the orbit of every planet may be considered as an ellipsis, which is undergoing slowly certain changes in its form, magnitude, and position, or in what are called its elements. By the elements of the orbit of any heavenly body, are meant the quantities that determine the position and magnitude of that orbit, viz. the position of the line of the nodes, the inclination of the plane of the orbit to the plane of the ecliptic, the position of the line of the apsides, the eccentricity, and the mean distance. These are all quantities independent of one another, and from them may be deduced all other circumstances with respect to the elliptic orbit. Of these five elements, which would be invariable, if the planet only gravitated to the sun, all, except the mean distance, are subject to slow, but perpetual changes.

45. The line of the nodes in every one of the planets, has a retrograde angular motion, which goes on continually, and of which the amount, when calculated as due to each planet, agrees very well with observation. The plane of the orbit also varies its inclination by certain small periodical changes which alternately increase and diminish it, as in the case of the moon. The line of the apsides, from the same cause as in the planet just mentioned, has a continued motion forward, or according to the order of the signs. Thus, in Mercury, the node goes back about 9″ annually. The aphelion goes forward about 6″ 2‴, and the inclination of the orbit in the course of a century, increases about 2″ 1‴, which, in the course of succeeding ages, will be compensated, by an equal diminution, so as to preserve it always nearly of the same quantity. In the same planet the equation of the centre, which depends on the eccentricity, increases about 20″ 1½ in a century, indicating a small increase of eccentricity. These variations in the orbit of Mercury, arise from the action of Venus, the Earth, Mars, Jupiter, and Saturn; the effects of the first of these planets, on account of its vicinity, being by much the most considerable. The mean distance, however, of Mercury from the Sun, does not, any more than that of the other planets, undergo any change whatever.

46. Similar conclusions apply also to the orbit of Venus. The orbit of the earth also is subject to similar changes, the line of the apsides moving forward annually at the rate of 11″ 8‴, in respect to the fixed stars. The earth's eccentricity is also diminishing, and the secular variation of the greatest equation of the centre is — 17″.66.

The motion of the earth is subject to another inequality on account of the action of the moon; for, to speak strictly, it is not the centre of the earth, but the centre of gravity of the moon and earth, which describes equal areas in equal times about the centre of the sun. It is evident, that, on this account, the earth will be sometimes advanced before, and sometimes will fall behind, the point which describes the circumference of the ellipsis, in conformity with the general law of the planetary motions. From the same cause also, as the moon does not move in the plane of the ecliptic, the earth will be forced out of that plane, in order to preserve a position diametrically opposite to the moon. These irregularities, however, are inconsiderable. By observers on the earth's surface, they are transferred to the sun, but in an opposite direction. The sun, therefore, has a motion in longitude, by which he alternately advances before the point which describes the elliptic orbit in the heavens, and falls behind it, and also a motion in latitude, by which he alternately ascends above, and descends below the plane of the ecliptic. As the mass of the moon, however, is not more than $\frac{1}{68.5}$ part of that of the earth, the distance of the centre of gravity of the moon and earth, from the centre of the latter, must be less than a semidiameter, and therefore the inequality thus produced in the sun's longitude, must be less than his horizontal parallax. The alteration in latitude can hardly amount to a second. This inequality in the sun's motion is called the menstrual parallax, and was first mentioned by Smeaton, *Phil. Trans.* 1768.

47. In the orbit of Mars, the node moves backward 23″ 1 annually, and the line of the apsides moves forward 16″ 3, both in respect of the fixed stars. The eccentricity of the orbit is diminishing, and the secular variation of the greatest equation of the centre is — 37″.

In the case of this planet, however, the elliptic orbit is not only changed by these quantities, but the place of the planet in that orbit is sensibly affected by the action of Venus, Jupiter, and the Earth. The effect of the action of Venus is expressed by this formula 5″.7 sin. (long. ♀ — 3 long ♂); of the earth, 7″.2 sin. (long. ⊙ — long. ♀). Several inequalities are produced by Jupiter.

48. The inequalities of the small planets *Vesta*, *Juno*, *Ceres*, and *Pallas*, have not yet been computed; the disturbances which they must suffer from Mars and Jupiter, are no doubt considerable, and, on account of their vicinity, though their masses are small, they may somewhat disturb the motions of one another. Their action on the other bodies in the system is probably insensible.

As two of these planets have nearly the same periodic time, they must preserve nearly the same distance, and the same aspect with regard to one another. This offers a new case in the computation of disturbing forces, and may produce equations of longer periods than are yet known in our system.

The motion of the apsides and the change of eccentricity in the orbits of Jupiter and Saturn are chiefly produced by their action on one another, but a part also depends on the action of the other planets. The node of Jupiter moves backward annually 19½″, and his aphelion forward 6″.58. The secular change in the inclination of the orbit is 27″, and in the first and last of these inequalities the action of Venus has the principal share. The equation of the centre increases 56¼″ in a century, of which nearly the whole arises from the action of Saturn. In Saturn again the node goes back at the rate of 21″ annually, and the aphelion forward at the rate of 16″, the secular change of the inclination is — 23″, and the secular diminution of the equation of the centre 1′ 50″.

There is, beside these variations in the orbits, an inequality in the motion of each of these planets, which it has been found very difficult to explain, and has only lately been fully accounted for, according to the theory of gravity, by the profound investigations of La Place. These inequalities are both of a long period, viz. 918.76 years, which is the time that they take to run through all their changes. If $n$ express a number of years reckoned from the beginning of 1750, S the mean longitude of Saturn, and I that of Jupiter, reckoned from the same time, then the equation which must be applied to the mean longitude of Jupiter, or the amount of this inequality, is

$$+(20' \, 49''.5 - n \times 0''.042733) \times \sin(5\,S - 2\,I + 5^0 \, 34' \, 8'' - n \times 58''.88)$$

and that which must be applied to S, is

$$-(48' \, 44'' - n \times 0''.1) \times \sin(5\,S - 2\,I + 5^0 \, 34'.8'' - n \times 58''.88).$$

These two equations are to one another nearly in the ratio of 3 to 7. The reason of the long period above mentioned is, that the argument $5S - 2I - n \times 58''.88$, requires all that time to increase from 0 to 360°.

Uranus, on account of his great distance, suffers hardly any disturbance in his motion, but from Saturn and Jupiter. The node moves backward at the rate of $34''\frac{1}{4}$ annually, and the aphelion forward at that of $2''.55$. The eccentricity is increasing, and the secular variation of the greatest equation of the centre is $11''.03$.

There is also an inequality in the longitude of this planet depending on the action of Saturn. If S be the longitude of this last planet, U the longitude of Uranus, and A the longitude of the aphelion of Saturn, the inequality in question amounts to $2'.30'' \times \sin (S - 2U + A)$.

49. *Of all these inequalities, and of many other smaller ones which theory has discovered, it must be observed that they are periodical, each returning after a certain time to run through the same series of changes which it had formerly exhibited.*

*Another general remark is, that one element in every planetary orbit, viz. the mean distance, is exempted from all change; and since on the mean distance depends the time of revolution, that time remains also unchanged. From the invariability of the mean distance, and the periodical revolution of all the inequalities, it follows that the actual condition of the planetary system can never deviate far from the mean, about which, we may, therefore, conceive it to be continually making small oscillations, which, in the course of ages, compensate one another; and, therefore, produce nothing like disorder or permanent change. It is in this manner that the stability of the planetary system is provided for by the wisdom of its Author.*

50. *Comets*, in describing their elliptic orbits round the sun, have been found to be disturbed by the action of the larger planets, Jupiter and Saturn; but the great eccentricity of their orbits makes it impossible, in the present state of mathematical science, to assign the quantity of that disturbance for an indefinite number of revolutions, though it may be done for a limited portion of time, by considering the orbit as an ellipsis, the elements of which are continually changing. This is the method of La Grange, and is followed in the *Mecanique Celeste*, Part II. chap. 9. Dr Halley, when he predicted the return of the comet of 1682, took into consideration the action of Jupiter, and concluded that it would increase the periodic time of the comet a little more than a year; he therefore fixed the time of the re-appearance to the end of the year 1758, or the beginning of 1759. He professed, however, to have made this calculation hastily, or, as he expresses it, *levi calamo*. (*Synopsis of the Astronomy of Comets.*)

The effects both of Jupiter and Saturn on the return of the same comet were afterwards calculated more accurately by Clairaut, who found that it would be retarded 511 days by the action of the former planet, and 100 by the action of the latter; in consequence of which, the return of the comet to its perihelion would be on the 15th of April 1759. He admitted, at the same time, that he might be out a month in his calculation. The comet actually reached its perihelion on the 13th of March, just 33 days earlier than was predicted; affording, in this way, a very striking verification of the theory of gravity, and the calculation of disturbing forces. The same comet may be expected again about the year 1835.

In some instances, the effect which the planets produce on the motion of comets are far more considerable than in this example. A comet which was observed in 1770 had a motion which could not be reconciled to a parabolic orbit, but which could be represented by an elliptic orbit of no great eccentricity, in which it revolved in the space of five years and eight months. This comet, however, which had never been seen in any former revolution, has never been seen in any subsequent one. On tracing the path of this comet, Mr Burckhardt found that, between the year 1767 and 1770 it had come very near to Jupiter, and had done so again in 1779. He therefore conjectured, that the action of Jupiter may have so altered the original orbit as to render the comet for a time visible from the earth; and that the same cause may have so changed it, after one revolution, as to restore the comet to the same region in which it had formerly moved. This is the greatest instance of disturbance which has yet been discovered among the bodies of our system, and furnishes a very happy, as well as an unexpected, confirmation of the theory of gravity.

Though the comets are so much disturbed by the action of the planets, yet it does not appear that their re-action produces any sensible effect. The comet of 1770 came so near to the earth as to have its periodic time increased by two days .246 according to *La Place's* computation, and if it had been equal in mass to the earth it would have augmented the length of the year by not less than two hours and forty-eight minutes. It is certain that no such augmentation took place, and therefore that the disturbing force by which the comet diminished the gravity of the earth is insensible, and the mass of the comet, therefore, less than $\frac{1}{500}$th of the mass of the earth. The same comet also passed through the middle of the satellites of Jupiter. Hence it is reasonable to conclude, that no material or even sensible alteration has ever been produced in our system by the action of a comet.

### 3. *Of the disturbances which the satellites of Jupiter suffer from their action on one another.*

51. The same resolution of the forces by which one satellite acts upon another, into two, one directed to the centre of the primary, and the other at right angles to it, serves to explain the irregularities which had been observed in their motions, and to reduce under known laws, several other inequalities, of which the existence only is indicated by observation.

An instance of this we have in the very remarkable relation which takes place between the mean motions of the first three satellites; the mean motion of the first satellite, together with twice the mean motion of the third, being equal to three times the

mean motion of the second. La Place has shown that, if the primitive mean motions of these satellites were nearly in this proportion, the mutual action of these bodies on one another must, in time, have brought about an accurate conformity to it.

The first satellite moves nearly in the plane of Jupiter's equator, and has no eccentricity, except what is communicated from the third and fourth, the irregularities of one of these small planets producing similar irregularities in those that are contiguous to it. The first satellite has beside an inequality, chiefly produced by the action of the second, and circumscribed by a period of 437.659 days.

52. The orbit of the second satellite moves on a fixed plane, to which it is inclined at an angle of 27′ 13″, and on which its nodes have a retrograde motion, so that they complete a revolution in 29.914 years. The motion of the nodes of this satellite, is one of the principal data used for determining the masses of the satellites themselves, which are so necessary to be known for computing their disturbances. This satellite has no eccentricity but that which it derives from the action of the third and fourth. The third satellite moves on a fixed plane, to which it is inclined at an angle of 12′ 20″, and its nodes make a tropical revolution backwards in 141.739 years. The equator of Jupiter is inclined to the plane of his orbit at an angle of 3° 5′ 27″. The fixed planes on which the planes of the orbits move are determined by theory, and could not have been discovered by observation alone.

The orbit of the third satellite is eccentric, but appears to have two distinct equations of the centre; one which really arises from its own eccentricity, and another which theory shows to be an *emanation*, from the equation of the centre of the fourth satellite. The first equation is referable to an apsis, which has an annual motion of 2° 36′ 39″ forward in respect of the fixed stars; the second equation is referable to the apsides of the fourth satellite.

These two equations may be considered as forming one equation of the centre, referable to an apsis that has an irregular motion. The two equations coincided in 1682, and the sum of their *maxima* was 13′ 16″. In 1777, the equations were opposed, and their difference was 5′ 6″.

The two last inequalities were perceived by Mr Wargentin by observation alone, but their exact amount, and the law which they observe in their changes, he could not discover. The orbit of the fourth satellite moves on a fixed plane, to which it is inclined at an angle of 14′ 58″, and its nodes complete a sideral revolution backward in 531 years. The fixed plane on which the orbit moves is inclined at an angle of 24′ 33″ to the equator of Jupiter; the orbit is sensibly elliptical, and its greater axis has an annual motion of 43′ 35″. The motion of this axis is one of the principal data from which the quantities of matter of the different satellites have been determined.

If the mass of Jupiter be supposed unity, the mass of the 1st Satellite = .0000173281.
Of the 2d = .0000232355.
Of the 3d = .0000884972.
Of the 4th = .0000426591.

If the mass of the earth be supposed unity, that of the third satellite will be found = .027337; and, as the mass of the moon is $\frac{1}{68.5}$, = .014599, the quantity of matter in the third satellite is about twice as great as that in the moon. The fourth satellite is therefore nearly equal to the moon; the second about one half, and the first somewhat more than one third.

53. The general result of this investigation concerning the inequalities in the motion of the planets, both primary and secondary, is, that in every one of these orbits, two things remain secure against all disturbance, the mean distance and the mean motion; or, which is the same, the transverse axis of the orbit, and the time of the planet's revolution. Another result is, that all the inequalities in the planetary motions are periodical, and observe such laws, that each of them, after a certain time, runs through the same series of changes. This last conclusion follows from the fact, that every inequality is expressed by terms of the form $A \sin nt$ or $A \cos nt$, where $A$ is a constant co-efficient, and $n$ a certain multiplier of $t$ the time, so that $nt$ is an arch of a circle, which increases proportionally to the time. Now, in this expression, though $nt$ is capable of indefinite increase, yet, since $nt$ never can exceed the radius or 1, the maximum of the inequality is A. Accordingly, the value of the term $A \sin nt$ first increases from 0 to A, and then decreases from A to 0; after which it becomes negative, extends to — A, and passes from thence to 0 again. If, when the inequality was affirmative, it was an addition to the mean motion, when negative, it will become a diminution of it; and the sum of all these increments and decrements, after $nt$ has passed over an entire circumference or 360°, is equal to 0; so that, at the end of that period, the planet is in the same position as if it had moved on regularly all the while, at the rate of the mean motion. As this happens to every one of the inequalities, the deviation of the system from its mean state can never go beyond certain limits, each inequality in a certain course of time destroying its own effect.

It would be far otherwise, if into the value of any inequalities, a term entered of the form $A \times nt$, $A \tan nt$, $\frac{A}{\sin nt}$. The inequalities so expressed would continually increase with the time, so as to go beyond any assignable limit, and of consequence to destroy entirely the order of any system to which they belonged.

La Grange and La Place, who discovered and demonstrated, that no such terms as these last can enter into the expression of the disturbances which the planets produce by their action on one another, made known one of the most important truths in physical science. They proved that the planetary system is stable, that it does not involve any principle of destruction in itself, but is calculated to endure for ever, or till the action of an external power shall put a period to its existence. After the knowledge of the principle of gravitation, this may be fairly considered as the greatest discovery to which men have been led by the study of the heavens.

The accurate compensation, just remarked, depends on three conditions, belonging to the primitive or original constitution of our system, but not necessarily determined, inasmuch as we know, by any physical principle. The first of these conditions is, that the eccentricities of the orbits are all inconsiderable, or contained within very narrow limits, not exceeding in any instance $\frac{1}{10}$ or $\frac{1}{8}$ part of the mean distance. The second condition is, that the planets all move in the same direction, or from west to east. This is true both of the primary and secondary planets, with the exception only of the satellites of Uranus, which may be accounted retrograde, but their planes being nearly at right angles to the orbit of their primary, the direction of their motion, whether retrograde or otherwise, can have little effect. Lastly, the planes of the orbits of the planets are not much inclined to one another. This is true of all the larger planets, though it does not hold of some of the new and smaller ones; of which, however, the action on the whole system must be wholly insensible.

Unless these three conditions were united in the constitution of the solar system, terms of the kind just mentioned, admitting of indefinite increase, might enter into the expression of the inequalities, which would indicate a gradual and unlimited departure from the original order and constitution of the universe. Now, the three conditions just enumerated, do not necessarily arise out of the nature of motion, or of gravitation, or from the action of any physical cause with which we are acquainted. Neither can they be considered as arising from chance, for the probability is almost infinite to one, that, without a cause particularly directed to that object, such a conformity could not have arisen in the motions of thirty-one different bodies, scattered over the whole extent of the solar system. *The only explanation, therefore, that remains is, that all this is the work of intelligence and design, directing the original constitution of our system, and impressing such motions on the parts as were calculated to give stability to the whole.*

For some farther particulars, connected with *Physical Astronomy*, see EARTH, FIGURE OF, in this Supplement. (L.)

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ASTRONOMY, PRACTICAL. See the article OBSERVATORY, in this Supplement.

ATMOMETER (from *ατμος, vapour*, and *μετρον, a measure*), an instrument lately contrived by Professor Leslie, for measuring the quantity of moisture exhaled from any humid surface in a given time. It consists of a very thin ball of porous earthen-ware, from one to three inches in diameter, having a small neck firmly cemented to a long and rather wide tube of glass, to which is adapted a brass cap, with a narrow collar of leather to fit close. Being filled with distilled or pure water, the waste and descent of this column serves to indicate the quantity of evaporation from the external surface of the ball. The tube is marked downwards through its whole length by the point of a diamond, with divisions across it, amounting from 200 to 500, each of which corresponds to a ring of fluid, that, spread over the whole exhaling surface, would form a film only one thousand part of an inch in thickness. This graduation is performed by previously sealing one of the ends of the tube with wax, and introducing successive portions of quicksilver, to mark every 20, 50, or 100 of those divisions; being calculated of equal bulk to discs of water, that have the surface of the ball (exclusive of the neck) for their base, and so many thousand parts of an inch for their altitude.

The instrument, being thus constructed, has its cavity filled with pure water, and its cap screwed tight, and is then suspended freely out of doors, sheltered indeed from rain, but exposed to the action of the wind. The water transudes through the porous substance of the ball, just as fast as it evaporates from the external surface; and this waste is measured by the corresponding descent of the liquid in the stem. At the same time, the column is suspended in consequence of the tightness of the cap, and prevented from oozing so freely as to drop from the ball. As the process of evaporation goes on, minute globules of air, separated by the removal of atmospheric pressure from the body of the water, or partly introduced by external absorption, continue to rise in fine streamlets to the top, where they partially occupy the space left by the subsidence of the fluid column. We need scarcely observe, that, after the water has sunk to the bottom of the stem, it will be requisite again to fill the cavity.

It is a fact of main importance for the accuracy of the Atmometer, that the rate of evaporation is nowise affected by the quality of the porous ball, and continues precisely the same, whether the exhaling surface appears almost dry or glistens with excess of moisture. This rate must evidently depend on the effect of the dryness of the air combined with its quickness of circulation. In a close room, the instrument might therefore serve the purpose of an hygrometer; and, placed out of doors, first screened, perhaps, for an hour, and then exposed during an equal space of time, it would furnish data for calculating the velocity of the wind.

This elegant instrument is of extensive application, and great practical utility. To ascertain readily and accurately the rate of evaporation from any surface, is an important acquisition, not only in Meteorology, but in Agriculture, and in the various mechanical arts. The quantity of exhalation from the surface of the ground is not of less consequence than the measure of the fall of rain, and a knowledge of it might often direct the farmer advantageously in his operations. On the rapid dispersion of moisture, depends the efficacy of drying-houses, which are generally constructed on most erroneous principles.

We shall select a few observations made with the Atmometer, from a register kept last season at Abbotshall, near Kirkcaldy in Fifeshire, by the very intelligent gardener of Robert Ferguson, Esq. of Raith. During the months of July, August, September, October, and November, the mean quantity of evaporation, in twenty-four hours, was respectively .111,—.090, .060,—.045, and—.022; and distinguishing the whole interval into equal spaces of twelve hours, from six o'clock in the morning to six

Fig. 1.

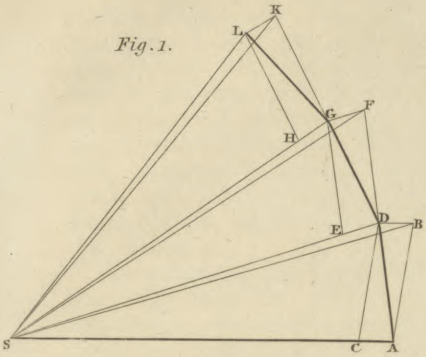



Fig. 2.

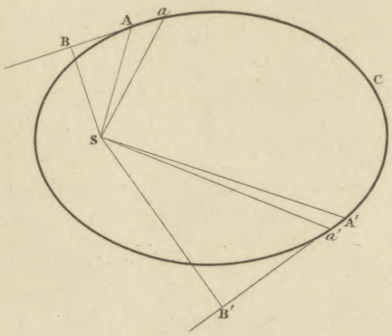



Fig. 3.

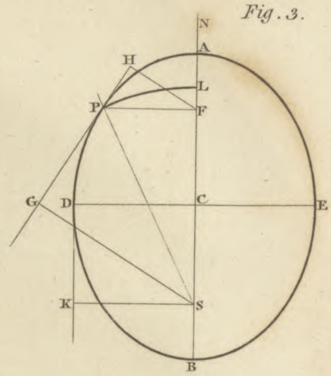



Fig. 4.

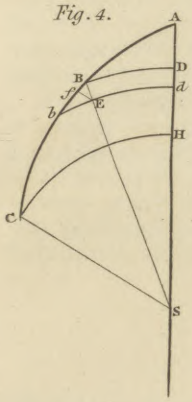



Fig. 5.

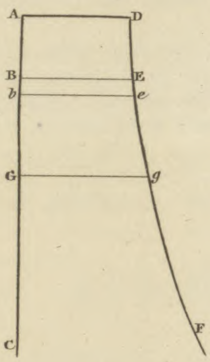



Fig. 6.

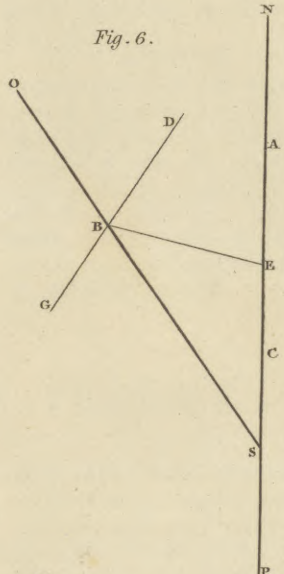



Fig. 7.


Fig. 8.

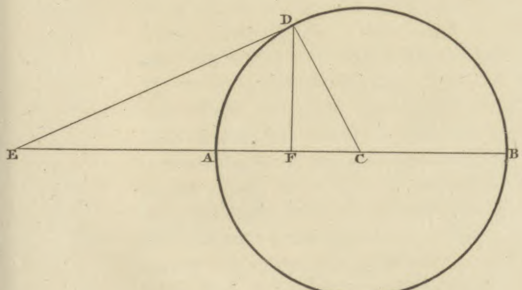



Fig. 9.

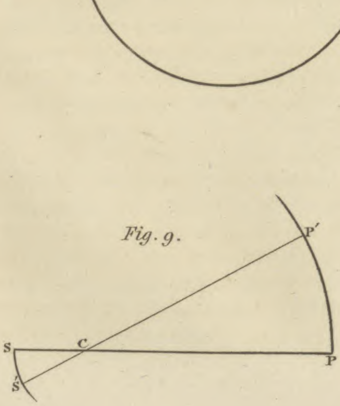



Fig. 11.

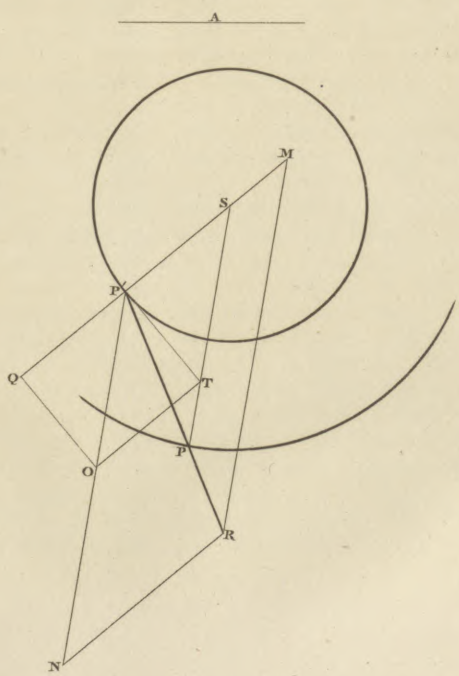
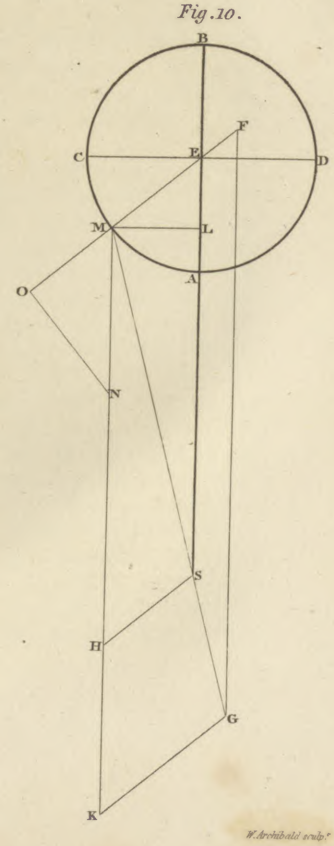
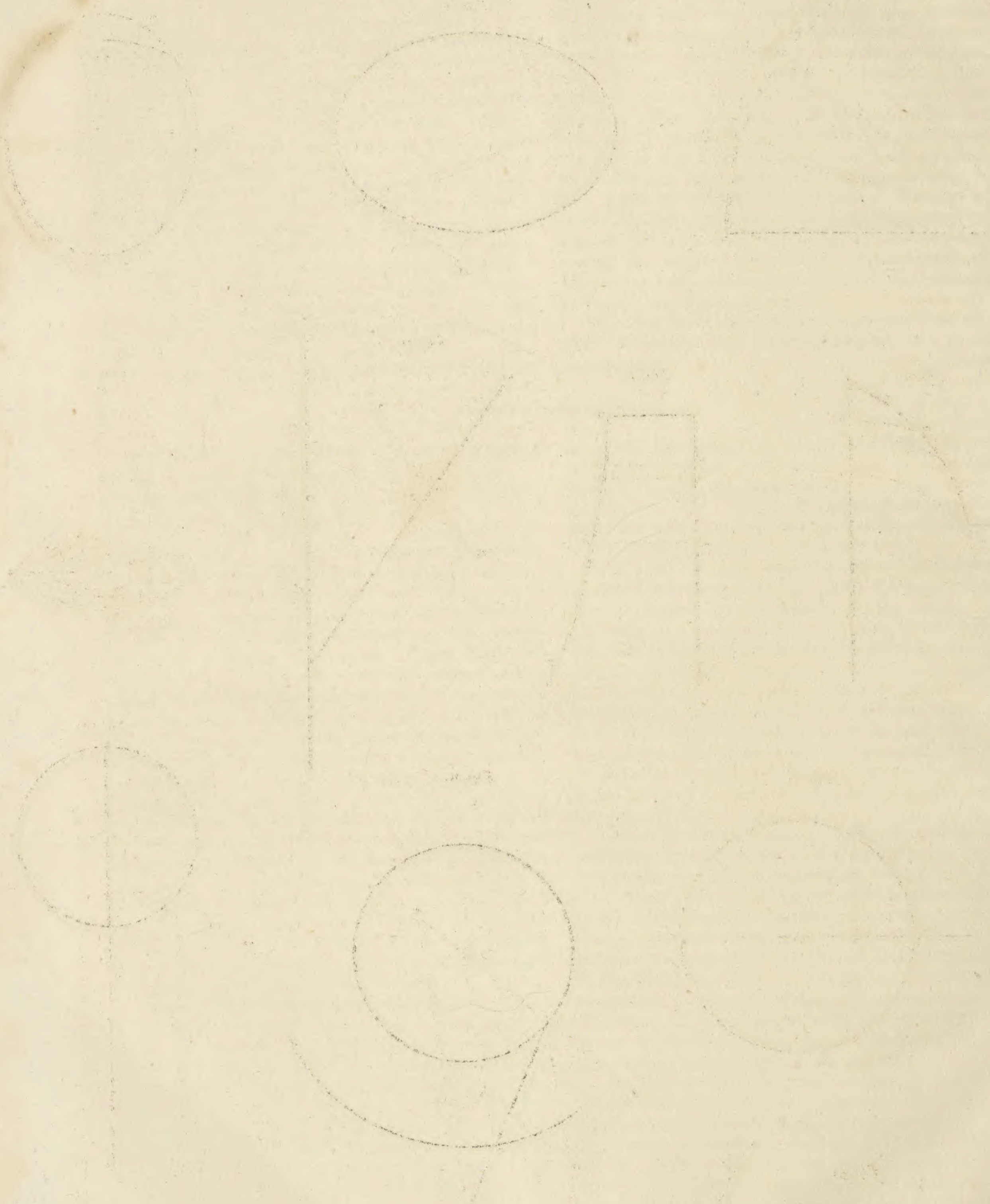



Fig. 10.




Published by A. Constable & Co. 1816.

W. Archibald sculp.



Atmometer. o'clock in the evening, for the measure of the day and of the night; the corresponding results are .092, .029, —.078, .012,—.050, .010,—.032, .013, .020. On the 21st of July 1815, the quantity of evaporation, during twenty-four hours, was 208; and, on the 27th of the same month, it was 200, the thermometer having sunk as low during the night as 46° and 49° of Fahrenheit's scale.—If we reckon the mean daily evaporation through the year at .040, this would give $14\frac{6}{10}$ inches, for the whole amount, or about half the annual quantity of rain that falls in this climate.

The atmometer, in its most compendious form, is admirably fitted for delicate experiments on the evaporation which takes place in close vessels, when absorbent substances are introduced. Let the ball of the instrument, for example, be immersed in air variously rarefied or condensed, under a receiver covering a surface of sulphuric acid, which has different degrees of strength; and, things being thus disposed, on extracting the common air, and introducing hydrogen gas, the rate of evaporation will then be nearly tripled. But we purpose to take some future opportunity of stating the results of such curious and interesting researches.

We shall close this short notice, with mentioning a striking fact, which shows the necessity of extreme caution in all physical inquiries. Let the ball of an atmometer be cemented to a narrow glass tube of three or four feet in length, and the whole capacity filled with fresh distilled water. Now invert the instrument upright in a basin of quicksilver, and secure it in that situation; the quicksilver, following the column of water, will rise at first quickly, and then by degrees more slowly till it reaches, perhaps, an elevation of 28 inches, where it will remain stationary and afterwards sink down, when the evaporation is nearly spent. Ice-water is raised in this way about 26 inches only, and common water scarcely 24 inches; the air separated from such liquids forming near the top of the ball, a thin medium, which, by its elasticity, counteracts in part the pressure of the external atmosphere supporting the mercurial column. But a similar experiment, where the shoot of a vine was cemented to a tube holding quicksilver, has been thought, by Dr Hales and M. Du Hamel, quite conclusive, in proving the *power* of the living principle of vegetation. It is obvious, that the force of evaporation alone was sufficient to explain the facts advanced by those ingenious philosophers. See Leslie's *Short Account of Experiments and Instruments depending on the Relations of Air to Heat and Moisture*. (D.)

ATMOSPHERE. We have to regret, that the experiments to which we alluded, in referring from AIR to this article, are not yet completed; and must again postpone the consideration of the various points connected with this subject, till other opportunities shall occur, particularly under the articles CLIMATE and METEOROLOGY. There are already articles of some extent, both on AIR and ATMOSPHERE, in the *Encyclopædia*, to which we beg, in the meantime, to refer our readers.

# ATOMIC THEORY.

ATOMIC THEORY, a species of philosophy lately introduced into *Chemistry*, which deserves to be fully explained in this place.

History. It is well known to have been the doctrine of some of the most eminent of the Greek philosophers, that the ultimate elements of matter consisted of *atoms* or particles incapable of farther division or diminution. This doctrine was adopted by Sir Isaac Newton, and, indeed, has been almost universally embraced by modern philosophers. But it was in *chemistry* alone that it could be applied with any advantage. The object of chemists was to determine the component parts of bodies, and to ascertain the different elements out of which all substances are compounded. Considerable progress was gradually made in this difficult investigation. Thus it was soon ascertained that the *salts*, which constitute a very numerous class of bodies, contain always at least two constituents, namely, an *acid* and a *base*. Thus, saltpetre is a compound of the acid called *nitric acid*, and the base called *potash*. Now, how small a portion soever of saltpetre you examine, whether a grain or the millionth part of a grain, you will always find it to contain both the ingredients of which saltpetre is composed. The same thing holds with respect to all the other salts, and, indeed, with respect to all compound bodies whatever. Now, this could not be the case, unless these compounds were formed by the union of the minutest possible particles of the constituents with each other; that is to say, unless it were the ultimate atoms of the elements which united together and constituted the compound. Accordingly, it has been admitted as an axiom in chemistry, that *chemical union consists in the combination of the atoms of bodies with each other*.

Chemistry originated from the absurd pursuits of the alchymists; and many years elapsed before it was able to shake off its connection with the chimerical notions respecting the *philosopher's stone* and the *universal medicine*. Dr Cullen was perhaps the first man that viewed the science as constituting a great and important branch of natural philosophy. His views were followed out by Black, Cavendish, Priestley, and a cloud of other eminent men, who have added so much lustre to the scientific pre-eminence of Great Britain. Margraaf, Bergman, and Scheele, were the first scientific chemists who appeared on the Continent. Bergman, in particular, was of the most essential service to the science. Educated in those branches of mechanical philosophy which had already made such progress, and accustomed to the rigid accuracy of mathematical reasoning, he introduced the same correct views, the same precise reasoning, the same generalization to which he had been already

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habituated. Lavoisier, who had the advantage of a similar education, adopted a similar conduct. His industry was indefatigable, and he contributed much more than any other person to introduce that precision in experimenting, and that accuracy of reasoning, which characterize the chemists f the present day.

The exertions of these eminent men led to the discovery of the art of analysis, such, though in a rude state, as it is practised at present. Bergman, Kirwan, and Wenzel, particularly distinguished themselves by the analysis of the salts. Of these three, Wenzel is by far the most accurate. The result of their experiments was, the demonstration that salts, and, indeed, all compound bodies, are universally composed of the same constituents united in the same proportions. Thus, water is always a compound of 1 part by weight of hydrogen, and $7\frac{1}{2}$ parts of oxygen; sulphate of copper always contains equal weights of sulphuric acid and black oxide of copper; and sulphate of barytes is always a compound of 100 parts by weight of sulphuric acid, and 194 of barytes.

Discovery of Richter.

J. B. Richter, who was for sometime Mining Secretary at Breslau, and afterwards *Arcanist* in the Porcelain manufactory at Berlin, where he died on the 4th of April 1807, employed himself, during the whole of his life, in endeavouring to introduce the use of mathematics into chemistry. His inaugural dissertation, printed in 1789, was entitled *De usu mamathescos in chymia*. In the year 1792, he published the first part of a work entitled *Anfangsgründe der Stochiometrie, oder Messkunst chymischer Elemente; Foundation of Stochiometry, or geometry of the chemical elements*. This work he continued to publish in successive parts, in 1793, 1794, 1795, 1802. Richter observed, that when two neutral salts, which mutually decompose each other, are mixed together, the two new salts which are formed still retain the same neutral state as the two original ones from which they were formed. Thus, *sulphate of potash*, and *nitrate of barytes*, are two neutral salts, which decompose each other when mutually mixed; *sulphate of barytes*, and *nitrate of potash*, being formed both in a neutral state. This circumstance enabled him to examine the accuracy of the results obtained by preceding experimenters, and he showed that the numbers assigned both by Bergman, Kirwan, and Wenzel, for the constituents of the salts, were inaccurate, as they were unable to stand the test of this double decomposition. He was induced, in consequence, to make a new set of experiments, in order to determine the constituents of the salts with more precision, and these experiments occupied him about ten years. He first analyzed the alkaline and earthy muriates and sulphates, then the nitrates, then the fluates, then the carbonates, oxalates, succinates, tartrates, citrates, acetates, and some others; and lastly the phosphates. He placed in a table the quantity of each of the bases required to saturate 100 parts of muriatic acid, beginning with that base of which the smallest quantity was necessary for the purpose, and terminating with the base of which the greatest quantity was requisite. Similar tables were drawn up, representing the weight of the different bases requisite to saturate 100 parts of sulphuric acid, nitric acid, carbonic acid, and all the other acids contained in the different genera of salts which he had subjected to analysis. A comparison of these tables with each other enabled him to draw the two following remarkable consequences: *First*, The different bases follow exactly the same order in all the tables, and that order is as follows:

Alumina.
Magnesia.
Ammonia.
Lime.
Soda.
Strontian.
Potash
Barytes.

*Second*, The numbers in each table constitute a series, which have the same ratio to each other in all the tables. Suppose, for example, that in the table representing the muriates, the quantity of potash requisite to saturate 100 parts of muriatic acid were three times as great as the quantity of alumina requisite to produce the same effect, the same thing would hold in the sulphates, nitrates, and all the other genera of salts. Three times as much potash would be requisite to saturate 100 sulphuric, nitric, or any other acid, as would be required of alumina. In the same way, if three times as much barytes be requisite to saturate a given weight of one acid as is required of lime, the same proportion will hold when we saturate any other acid; with these earths we must always employ three times as much barytes as of lime. When the quantity of each of the acids requisite to saturate a given weight of each successive base, was placed in tables in a similar way, it was found, as might have been anticipated, that the acids followed precisely the same law.

These facts explain why, when two neutral salts decompose each other, the new formed salts are also neutral, and why there is never any excess of acid or base upon the one side or the other. The same proportions of bases that saturate a given weight of one acid, saturate all the other acids, and the same proportion of acids that saturate one base, saturate all the other bases. Hence numbers may be attached to each acid and base, indicating the weight of it which will saturate the weights attached to all the other bases or acids. This accordingly was done by Fischer from Richter's experiments and tables. We shall here insert his numbers, not because they are accurate, which is very far from being the case, but because they constitute the first specimen of the kind ever offered to the chemical world. (Berthollet's *Essai de Statique Chimique*, I. 136.)

| | | | |
|---|---|---|---|
| Alumina, | 525 | Fluoric acid, | 427 |
| Magnesia, | 615 | Carbonic acid, | 577 |
| Ammonia, | 672 | Sebacic acid, | 706 |
| Lime, | 793 | Muriatic acid, | 712 |
| Soda, | 859 | Oxalic acid, | 755 |
| Strontian, | 1329 | Phosphoric acid, | 979 |
| Potash, | 1605 | Formic acid, | 988 |

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| | | | |
|---|---|---|---|
| Barytes, | 2222 | Sulphuric acid, | 1000 |
| | | Succinic acid, | 1209 |
| | | Nitric acid, | 1405 |
| | | Acetic acid, | 1480 |
| | | Citric acid, | 1583 |
| | | Tartaric acid, | 1694 |

According to this table, 525 of alumina is saturated by 427 of fluoric acid, 577 of carbonic acid, 755 of oxalic acid, 1000 sulphuric acid, &c.; and 427 of fluoric acid, is saturated by 525 of alumina, 615 of magnesia, 672 of ammonia, &c. It is obvious, therefore, that this table, supposing it accurate, would give us the composition of all the salts into which the bases and acids contained in it enter.

Discovery of Proust.

M. Proust, a French chemist of great sagacity, who was settled as Professor of Chemistry at Madrid, was the first person who attempted an accurate examination of metallic oxides. He studied the oxides of iron, zinc, arsenic, antimony, &c. The result of his examination was, that every metal is capable of forming a certain determinate number of oxides and no more. Zinc forms only one oxide; iron, arsenic, and antimony, form two each; tin forms three, &c. Each of these oxides he found composed of a determinate proportion of metal, and oxygen, which remained always the same in all cases. Thus, the oxide of zinc, according to him, is always a compound of 100 parts zinc, and 25 oxygen. The two oxides of iron are the *black* and the *red*. If iron be combined with oxygen at all, it is either connected with the quantity of oxygen which constitutes the black oxide, or with the quantity which constitutes the red oxide, but it is incapable of uniting with any other proportion of oxygen. Wherever iron, already in the state of black oxide, combines with more oxygen, it becomes red oxide, being incapable of existing in any intermediate state between the black and the red oxide. The same law holds with respect to tin, antimony, arsenic, and all the metals; thus, M. Proust proved that metals unite only with determinate proportions of oxygen, which may be assigned in numbers. He showed that the same law held with respect to the combinations of the metals with sulphur. When Berthollet published his *Chemical Statics*, one of his objects was to show that there are two proportions of oxygen which unite with metals, a minimum and a maximum, and that between these two extremes, usually placed at a considerable interval from each other, there are an infinity of proportions of oxygen capable of uniting with every metal. Hence he inferred that there is no such thing as permanent definite metallic oxides; but an infinite number of shades of oxydizement graduating into each other, and each capable of uniting with acids, and thus of forming an infinite variety of salts, differing from each other by minute shades of character. This extraordinary opinion, which, if correct, would have put an effectual period to all chemical investigation, as it would have been useless and absurd to attempt to examine compounds, which had no permanence and no analogy to each other, occasioned a discussion between Proust and Berthollet. Proust showed, by decisive experiments, that the indefinite numbers of metallic oxide, supposed by Berthollet, does not exist, and that metals are only capable of combining with 1, 2, or 3 dozes of oxygen; that there is no indefinite number of oxides between the black and the red oxides of iron; but that the instant that iron combined with more oxygen than existed in the black oxide, it is converted into the red oxide.

Discovery of Dalton.

Such was the state of the subject when Mr Dalton turned his attention to the combination of bodies with each other about the year 1804. At that period, it was known that hydrogen combines only in one proportion with oxygen; that carbon, sulphur, and phosphorus, unite each in two proportions; that carbon unites in two proportions with hydrogen, sulphur in two proportions with the same substance, and phosphorus in one proportion; that azote unites in one proportion with hydrogen, and in four proportions with oxygen. It was known, too, that several of the metals combine with only one dose of oxygen, while some unite with two doses, and others with three. It had been ascertained, that, in certain cases, when metals combine with two doses of oxygen, the second dose is exactly double the first dose, while in other cases it is to the first dose as 3 to 2. Thus, in platinum, the second oxide contains just double the quantity of oxygen that the first oxide contains, while in iron, the quantity of oxygen in the red oxide, is, to the quantity in the black oxide, as 3 to 2. None of the combinations of oxygen or hydrogen, with the simple combustibles, had been accurately analyzed; though approximations to a correct analysis of most of them existed, and what was chiefly wanting, was a criterion for distinguishing the comparative merits of the different analysis of these bodies which had been presented to the chemical world.

Mr Dalton was struck with the small number of compounds which the elementary bodies are capable of forming with each other, and with the very simple relations which existed between the numbers that denote the weight of the different constituents in these compounds; and he set himself down to endeavour to account for these circumstances not hitherto inquired into.* Water, he found, was always a compound of 1 part by weight of hydrogen, and 8 parts by weight of oxygen.

| | | | | |
|---|---|---|---|---|
| Carbonic oxide is composed of | 750 | carbon | + | 1000 oxy. |
| Carbonic acid | 750 | | + | 2000 |
| Sulphurous acid | 2 | sulph. | + | 2 oxy. |
| Sulphuric acid | 2 | | + | 3 |
| Nitrous oxide | 175 | azote | + | 100 oxy. |
| Nitrous gas | 175 | | + | 200 |
| Nitrous acid | 175 | | + | 300 |
| Nitric acid | 175 | | + | 500 |

* In the following examples, instead of using the imperfect analysis with which Mr Dalton was obliged to be satisfied, and which misled him in some cases, we have thought it better to employ the most precise experiments hitherto made.

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Now, in all these compounds, it will be perceived, that the numbers denoting the oxygen, united to a given weight of the same base, bear a very simple and obvious ratio to each other. The oxygen in carbonic acid is twice as great as in carbonic oxide; the oxygen in sulphuric acid is to that in sulphurous as the numbers 3 to 2; while the oxygen, in the respective compounds of azote and oxygen, bears the ratio of the numbers 1, 2, 3, 5.

These and many other similar examples which Mr Dalton registered and examined, but which it is unnecessary to state here, led him to the lucky idea that the atoms of bodies unite together; that the atom of each body has a determinate weight, and that this weight regulates the proportion in which bodies combine with each other. Let us suppose, for example, that water is formed by the union of one atom of oxygen, with one atom of hydrogen, it follows, as the oxygen in water is 8 times that of the hydrogen, that the weight of an atom of oxygen is to that of an atom of hydrogen as 8 to 1. So that, if we represent the weight of an atom of hydrogen by 1, that of an atom of oxygen will be 8; or if, as is more convenient in practice, we pitch upon 1 for the weight of an atom of oxygen, an atom of hydrogen will weigh 0.125. As carbon unites with two proportions of oxygen, we may suppose that an atom of carbon unites with 1 atom, and with 2 atoms of oxygen. Hence, the reason why the quantity of oxygen in carbonic acid is twice as great as in carbonic oxide. If an atom of oxygen weigh 1, it is obvious that an atom of carbon will weigh 0.751, supposing the numbers which we have given in the preceding table to be accurate. It is equally obvious, that sulphurous acid must contain 2 atoms of oxygen, and sulphuric acid 3 atoms; and that an atom of sulphur will weigh 2, on the supposition that an atom of oxygen weighs 1. Finally, nitrous oxide is a compound of 1 atom azote, and 1 atom oxygen; nitrous gas of 1 atom azote, and 2 atoms oxygen; nitrous acid of 1 atom azote, and 3 atoms oxygen; and nitric acid of 1 atom azote, and 5 atoms oxygen. And, supposing the numbers in our table correct, if an atom of oxygen weigh 1, an atom of azote will weigh 1.75.

Mr Dalton did not rest satisfied with this simple and luminous explanation, which threw a new and strong light around chemical combinations,—which afforded the means of correcting and checking chemical experiments, hitherto conducted without any guide, and promised, in time, to introduce mathematical precision, and mathematical reasoning, into a science which hitherto has been able only to boast of analogical and probable conclusions. He contrived a set of symbols to represent the different elements, and make the nature of the combinations which they form obvious to the eye of the most careless reader. A few examples will be sufficient to make the nature and use of these symbols perfectly well understood.

Let ○ be an atom of oxygen
⊙ - - - - hydrogen
⦶ - - - - azote
◍ - - - carbon

Let ⊕ be an atom of sulphur
☮ - - - - phosphorus,

Then ⊙○ represents an integrant particle of water

| | |
|---|---|
| ◍○ - - - - | of carbonic oxide |
| ○◍○ - - - - - | of carbonic acid |
| ○⊕○ - - - - - | of sulphurous acid |
| ○<br>○⊕○ - - - - - | of sulphuric acid |
| ⦶○ - - - - - | of nitrous oxide |
| ○⦶○ - - - - - | of nitrous gas |
| ○<br>○⦶○ - - - - | of nitrous acid |
| ○○<br>○⦶○<br>○ - - - - | of nitric acid |
| ⊙◍⊙ - - - - - | of carbureted hydrogen |
| ◍⊙ - - - - - | of olefiant gas. |

It would be easy to multiply these symbols much farther; but the preceding specimen is sufficient, we conceive, to make the use of them understood, and even to make Mr Dalton's doctrine more simple to those who are still strangers to it. Mr Dalton has already published two volumes of what he entitles a *New System of Chemical Philosophy*, in order to explain and show the accuracy and importance of this doctrine. Our object, in the present article, will be to lay the whole of it in its present state before our readers. But we must, in the first place, trace the history of the improvements which it has received to its termination.

Improvements of Gay-Lussac and others.

In the year 1809, M. Gay-Lussac, who had already distinguished himself by many important chemical discoveries, and who was well acquainted with Mr Dalton's theory, published a curious paper on the combinations of gaseous substances with each other. (*Memoires d'Arcueil*, II. 205.) He showed that they follow a very simple law in their combinations; that one volume of one gas always combines either with one volume of another gas, or with two volumes, or with three volumes. Thus,

1 volume ammonia saturates 1 vol. of muriatic acid
1 vol. of carbonic acid
1 vol. of fluoboric acid.

The resulting compounds are neutral muriate, carbonate, and fluoborate of ammonia.

Nitrous gas is composed of one volume of azote, and one volume of oxygen.

Subcarbonate of ammonia is composed of one volume carbonic acid, and two volumes ammoniacal gas.

Subfluoborate of ammonia of one volume fluoboric acid, and two volumes ammoniacal gas.

Water of one volume of oxygen, and two volumes of hydrogen gas. Nitrous oxide of one volume oxygen, and two volumes azote. Nitric acid of one volume oxygen, and two volumes nitrous gas. Sulphuric acid of one volume oxygen, and two volumes sulphurous acid. Carbonic acid gas of one volume oxygen, and two volumes carbonic oxide.

Finally, ammonia is composed of one volume azote, and three volumes hydrogen; and nitrous acid gas of one volume oxygen, and three volumes of nitrous gas.

Gay-Lussac showed likewise, that the diminution of volume which takes place on the combination of these gases, follows as simple a law as the volumes in which they combine. In nitrous gas, the oxygen and azote undergo no condensation. Accordingly, the specific gravity of nitrous gas is the mean between that of oxygen and azote. Frequently one of the two gases retains its bulk unaltered, while the other totally disappears. Thus, when 100 measures of carbonic oxide, and 50 measures of oxygen gas, are united together by combination, the resulting compound constitutes 100 measures of carbonic acid. Sometimes the bulk is reduced to one half. Thus, when 100 measures of azote, and 300 measures of hydrogen, are united, they form 200 measures of ammoniacal gas.

This curious law, discovered by Gay-Lussac, when coupled with the doctrine of Mr Dalton, shows us, that there exists a very simple relation between the weight of the atoms and the bulk of the gaseous bodies. Accordingly, the weight of the atoms of these bodies may be deduced, with sufficient accuracy, from their specific gravity. This method was employed both by Sir Humphry Davy and Dr Wollaston.

Professor Berzelius of Stockholm, one of the most accurate and indefatigable chemists of the present time, was led, some years ago, to study the composition of the salts, in consequence of the perusal of Richter's *Stochiometry*. He soon satisfied himself that neither the analyses of Richter, nor of preceding chemists, could be depended on for accuracy. He resolved, therefore, to institute a new analysis of a considerable number of saline bodies, and to be at particular pains to ensure the greatest possible precision which the present state of the science enabled him to attain. The result of this laborious undertaking has been published in the *Annales de Chimie*, the *Annalen der Physik*, *Nicholson's Journal*, and the *Annals of Philosophy*. It constitutes by far the most complete and valuable set of chemical analyses of which the science is possessed. Berzelius not only satisfied himself of the accuracy of Richter's law, but was so fortunate as to discover another of a very unexpected nature, and of the greatest importance in chemical analysis, because it enables us to subject the results of all our analyses to calculation, and thus to determine with certainty how far their accuracy may be depended on. All the acids, with a very few exceptions, contain oxygen. This is the case likewise with all the salifiable bases, so that the salts may be considered as combinations of two sets of oxides with each other. Now, Berzelius compared the oxygen in the base of a salt with the oxygen in its acid, and he found that they always bore a very simple relation to each other. They were either equal, or the oxygen in the acid was twice as much as that in the base, or thrice as much, or four times as much, &c. If the acid contained twice as much oxygen as the base, this was a proof that the acid contained two atoms of oxygen; if it contained thrice as much, it contained three atoms of oxygen, and so on. Thus, in the sulphates, the sulphuric acid contains three times as much oxygen as the quantity of base which it saturates. Hence we infer, that sulphuric acid is a compound of 1 atom sulphur, and 3 atoms oxygen. In the sulphites, the acid contains twice as much oxygen as the base which it saturates. Hence, we infer that sulphurous acid is composed of 1 atom sulphur, and 2 atoms oxygen. In the carbonates, the oxygen in the acid is twice as much as in the base which it saturates. Hence we infer that carbonic acid is composed of 1 atom of carbon, and 2 atoms of oxygen.

Berzelius, during his experimental investigation of the atomic theory, met with some objections which he was not able immediately to surmount. In consequence of these difficulties, he substituted for the atomic theory what he calls the *theory of volumes*, derived from Gay-Lussac's discovery respecting the proportions in point of volume in which gaseous substances combine. This is merely substituting another name for the atomic theory. For it is easy to show, that the theory of volumes, as Berzelius considers it, is precisely the same thing as Dalton's atomic theory. The difficulties of Berzelius will come under our consideration hereafter.

After the preceding historical sketch, which we thought necessary in order to do justice to all parties concerned in this important branch of chemistry, we shall proceed to lay the atomic theory, with the proofs in support of it, before our readers.

### I. Outline of the Atomic Theory.

With respect to the nature of the ultimate elements of bodies, we have no direct means of obtaining accurate information. But it is the general opinion, that they consist of *atoms* or minute particles, incapable of farther division. It is impossible to demonstrate the truth of this opinion; but, for our part, we can conceive no other. It has been almost universally admitted, by mechanical philosophers, since the time of Newton. We shall, therefore, adopt it here as the foundation of our reasoning.

When two bodies unite chemically, so as to form a third body, the two substances combined are dispersed everywhere through the new compound. Water, for example, is composed of oxygen and hydrogen. Now, how minute a portion soever of water we examine, we shall find it to contain both oxygen and hydrogen. Saltpetre is a compound of nitric acid and potash. If we examine the salt, whether we take an ounce or the hundredth part of a grain, we shall always find it to be a compound of nitric acid and potash. If any portion of it were to want one of these constituents, it would no longer be saltpetre; it would be potash, or nitric acid, according to the constituent which is not present. Limestone is a compound of carbonic acid and lime. Now, we

may reduce it to an impalpable powder; but if we take one of the grains of this powder, however small, and throw it into nitric acid, we shall perceive an effervescence, indicating the presence of carbonic acid, and it will dissolve, indicating that lime was also one of its constituents. Mechanical trituration, however carefully made, is quite incapable of separating from each other substances which are chemically combined. Now, this distribution of the constituents could never be so complete through every part of the compound, unless it were the atoms of the combined bodies that united with each other. This, accordingly, is the opinion respecting chemical combinations, which appears always to have been entertained by chemical philosophers. Nor do we believe that any person will be disposed to call its truth in question.

All chemical compounds contain the same constant proportion of constituents with the most rigid accuracy, no variation whatever ever taking place. Water is universally a compound of 1 part by weight of hydrogen, and 8 of oxygen; sulphuric acid, of 1 part sulphur, and $1\frac{1}{2}$ oxygen; carbonic acid, of 1 part carbon, and 2.666 of oxygen. This permanency in the constituents of chemical compounds, indeed, is generally admitted. It constitutes, in fact, the basis of the whole science. For, if the proportions of the constituents of bodies were variable, chemical analysis would be nugatory, and the whole science of little importance. Even Berthollet, who contends for indefinite proportions in the abstract, admits the incontrovertible fact that the proportions of chemical combinations in general are permanent.

Since, then, bodies unite chemically atom to atom; and since they always unite in the same proportions, without the smallest deviation, this regularity can be ascribed to nothing else than the constant union of one atom of one body with one atom of another; or of a determinate number of atoms of one body with a determinate number of atoms of another. At first sight, it may appear impossible to determine how many atoms of each constituent combine with an indefinite number of atoms of the other. But there are some circumstances which afford us considerable assistance in this apparently intricate investigation.

Thus, oxygen has the property of uniting in different proportions with the same base; sometimes in two, sometimes in three, sometimes in four, &c. proportions. Thus, with carbon it unites in two proportions, with mercury in two, with copper in two. With tin it unites in three proportions, while with manganese it unites in four proportions. Now, if we represent the weight of base with which the oxygen unites by $a$, and suppose all the different proportions of oxygen to unite with this proportion of base; and if we denote the first portion of oxygen by $b$, then, in general, the constituents of the different compounds formed by the union of the different doses of oxygen with the base will be as follows:

1st compound $a + b$.
2d compound $a + 2b$.
2d compound $a + 3b$.
4th compound $a + 4b$.

Suppose 10 parts of oxygen enter into the first compound, then 20 parts enter into the second, 30 parts into the third, and 40 parts into the fourth compound. Hence, whatever number of atoms enter into the first compound, twice that number enters into the second compound, thrice the number into the third compound, and four times the number into the fourth compound. Hence it is clear, that there is a determinate number of atoms of oxygen, which always enter into these combinations. If we represent this number by $x$, then $a + x$ is the first compound, $a + 2x$ the second, $a + 3x$ the third, and $a + 4x$ the fourth. Now, it would be singular, if 2, 3, 4, &c. atoms of oxygen, were to be always inseparably linked together, so as never to be able to enter into combinations separate. It is much more simple to conceive, that $x$ represents only 1 atom. Indeed, there can be little doubt that this is actually the case. For oxygen gas, being a permanently elastic fluid, must consist of atoms that repel each other. Hence a compound atom of oxygen, or a number of atoms united together, seems to be impossible. But even though the opinion that $x$ represents one atom should not be mathematically true, still it would be proper to adopt it. For, as far as our calculations are concerned, a number of atoms of oxygen, constantly and invariably united together, would constitute a compound atom, about which we may reason as accurately and justly as we could do about the simple atoms themselves. But if $x$ in these combinations be considered as representing an atom of oxygen, there can be no doubt that $a$ represents an atom of the body, which unites with oxygen. So that, by knowing the proportions in which they unite, we have the relative weight of an atom of oxygen, and of the body with which it unites.

This reasoning may be applied to hydrogen as well as oxygen. Hydrogen has the property of uniting in different proportions with various bodies, as with carbon, phosphorus, sulphur, &c. In these different proportions, we find the hydrogen always denoted by $y$, $2y$, &c. just as is the case with oxygen. Hence we have the same reason for concluding that $y$, which represents the minimum of hydrogen which unites with the other constituent, is an atom.

The numbers $x$ and $y$ are easily discovered by making an accurate analysis of the different compounds into which various proportions of oxygen and hydrogen enter; and, when reduced to their lowest terms, they are very nearly $x = 8$, and $y = 1$. Hence these numbers represent the ratios of the weight of an atom of oxygen and an atom of hydrogen to each other. Now, it deserves attention, that these numbers represent the composition of water. For it has been ascertained, by very careful experiments, that water is composed of 100 measures of oxygen gas, and 200 measures of hydrogen gas. Now, the specific gravity of these gases is as follows:

| | |
|---|---|
| Oxygen, - - - | 1.111. |
| Hydrogen, - - - | 0.069. |

Hence water is composed by weight of

| | |
|---|---|
| Oxygen, - - - | 8.00. |
| Hydrogen, - - - | 1.00. |

From this coincidence we are entitled to conclude, that water is formed by the union of an atom of oxygen with an atom of hydrogen. And consequently, that an atom of hydrogen is to an atom of oxygen in weight, as 1 to 8. This very important conclusion is supported by other considerations. Oxygen and hydrogen have never been made to combine in any other proportion than that in which they exist in water. Hence this proportion must be that which unites most readily and with the greatest force. Now, as the atoms of hydrogen repel each other, as is the case also with the atoms of oxygen, it is obvious, that when they are mixed equably, as is the case when 200 measures of hydrogen gas, and 100 measures of oxygen gas, are put into a tube and fired by electricity, they will most readily unite atom to atom. This, though not in itself decisive, is a corroborating circumstance. It follows from it, that a given bulk of hydrogen gas contains only one half the number of atoms which exist in the same bulk of oxygen gas.

But we must not conceal that there is another view of this subject, which has been taken by Davy and Berzelius, and certainly possesses much plausibility. It is founded on this curious fact, first noticed, we believe, by Dr Wollaston, and confirmed by the theory of Gay-Lussac, detailed in the historical introduction to this article, that if we determine the weight of an atom of the gaseous bodies from their specific gravity (or at least a multiple of it), the numbers obtained will correspond with the atomic theory, as well as the numbers found by the method above described, which is the method of Dalton. In fact, they will always be the same numbers, or their halves or their doubles. This shows us, that a very simple relation exists between the bulk of a gas and the number of atoms which it contains. If the weight of an atom of a gas were always the same as its specific gravity, it would follow, that the same bulk of every gas contains always the same number of atoms. But cases occur in which this simple rule does not answer. Thus, it is admitted even by Davy and Berzelius, that the weight of an atom of azote is twice that of its specific gravity. So that, in a given measure of azotic gas, there is only one half of the number of atoms that exist in an equal measure of oxygen gas.

Those who found their weights of the atoms of bodies on the specific gravity of the gases, consider water as composed of 2 atoms of hydrogen, and 1 atom of oxygen. If this notion be correct, the weight of an atom of hydrogen, is to that of an atom of oxygen, as 1 to 16. This is nearly the proportion given by Davy and Berzelius. Davy, who rejects decimals, makes an atom of hydrogen weigh 1, and an atom of oxygen 15. Berzelius makes an atom of oxygen weigh 15.069, supposing that of hydrogen to weigh 1. As oxygen and hydrogen cannot be united in any other than 1 proportion, we have no means of putting it to the test of experiment. But the example of azote (admitted at least by Davy, though Berzelius, by his hypothesis, that azote is a compound of *nitricum* and oxygen, gets over the difficulty) is sufficient to show us that it is not necessary that the weights of the atoms of gases should be directly as the specific gravity of these bodies. On this account, the reasons before urged in favour of the opinion, that water is a compound of 1 atom of oxygen, and 1 atom of hydrogen, seems to us sufficient to give a preponderancy to this opinion, and to induce us to embrace it.

Knowing the weight of an atom of oxygen, and an atom of hydrogen, we have it in our power to determine the weight of an atom of the other substances, which unite with oxygen or with hydrogen, or with both. For example, 100 parts of sulphur unite with two proportions of oxygen, namely, with 100 parts constituting sulphurous acid, and with 150 parts constituting sulphuric acid, both by weight. Here, the proportions of oxygen being to each other as the numbers $1:1\frac{1}{2}$ or $2:3$; it is reasonable to suppose, that the first proportion represents 2 atoms of oxygen, and the second 3 atoms. There may, perhaps, exist another compound, consisting of 1 atom sulphur, and 1 atom oxygen, or by weight of 100 sulphur and 50 oxygen. But such a compound is at present unknown. It is evident, if sulphurous acid be composed of 1 atom sulphur, and 2 atoms oxygen, that an atom of sulphur is twice as heavy as an atom of oxygen. So that if we were to represent the weight of an atom of oxygen by 8, that of an atom of sulphur would be 16. Davy makes an atom of oxygen 15. Accordingly, his atom of sulphur is represented by 30.

We have it in our power to verify this reasoning by means of the combinations which sulphur makes with hydrogen. This verification may be made two ways, and we shall employ both to show how they serve to corroborate one another. 1. It has been ascertained, that 100 measures of hydrogen gas may be united to sulphur, and converted into sulphureted hydrogen gas, without undergoing any change of bulk. Hence, to know with precision the composition of sulphureted hydrogen, we have only to determine with care the specific gravity of hydrogen gas, and sulphureted hydrogen gas. Now,

100 cubic inches of hydrogen gas weigh 2.117 grains.
100 cubic inches of sulphur. hyd. gas 35.89.

Hence it follows, that sulphureted hydrogen gas is composed of

| | | |
|---|---|---|
| Hydrogen - - - | 2.117 | or 1.00 |
| Sulphur - - - - | 33.773 | 16.00 |

This shows us, that if sulphureted hydrogen gas is composed of 1 atom sulphur, and 1 atom hydrogen, and if we suppose an atom of hydrogen to weigh 1, an atom of sulphur will weigh 16. The combination of oxygen and sulphur gave us 16. Thus the two processes of reasoning lead to the same conclusion, since the difference really existing is greatly within the limits of the unavoidable errors in such kinds of experiment. 2. Sulphureted hydrogen gas requires for its complete combustion $1\frac{1}{2}$ times its bulk of oxygen gas. The products of the combustions are sulphurous acid and water. The sulphurous acid gas amounts exactly to the bulk of the sulphureted hydrogen gas consumed. Suppose 100 measures of sulphureted hydrogen gas to

be burned. We must employ for the purpose 150 measures of oxygen gas. The gaseous product consists of 100 measures of sulphurous acid gas; 100 measures of the oxygen gas go to the formation of the sulphurous acid gas, and 50 measures go to the formation of water. Now, 100 cubic inches of sulphurous acid gas weigh 66.89 grains, and contain 33.445 grains of sulphur; 50 cubic inches of oxygen combine with 100 cubic inches of hydrogen, or with 2.117 grains. So that, according to this analysis, sulphureted hydrogen is composed of

| | | | |
|---|---|---|---|
| Hydrogen - - | 2.117 | or | 1.000 |
| Sulphur - - - | 33.445 | | 15.8 |

So that, according to this determination, the weight of an atom of sulphur is 15.8. This differs only .2 from the preceding, and is also within the limits of the unavoidable errors of chemical experiment. We may, therefore, consider these two methods of determining the weight of an atom of sulphur as all coinciding, and giving absolutely the same result.

By a similar mode of reasoning, we may determine, with considerable accuracy, the weight of an atom of azote, phosphorus, carbon, the metals, and almost all those bodies which at present are considered as simple. It would be tedious to give any more illustrations here. Enough, we conceive, has been said to explain the nature of the theory, and to render the manner of proceeding in determining the weights of the atoms of bodies intelligible to the reader. In a future part of this article, we shall give a table of the weights of the atoms of bodies, and state, at the same time, the documents on which these weights are founded.

It is hardly necessary to observe, how very powerfully a particular conclusion is confirmed, when we arrive at it by different processes. This advantage we have in full perfection, when we set about determining the weight of the atoms of the simple substances. In most cases, we come to the same conclusions by two, three, or four different methods. These coincidences could not exist, unless the conclusions were well founded.

With respect to the number of atoms capable of uniting together, no general rule can be given. In organic bodies, this number is often very great. Hence, probably, the reason why we cannot succeed in our attempts to form animal and vegetable bodies. In unorganic bodies, the number of atoms united is much smaller. In primary compounds, we do not recollect an example of any substance containing more than 7 atoms. These atoms are always confined to two different kinds of matter, as *hydrogen* and *oxygen*, *carbon* and *oxygen*, *sulphur* and *oxygen*, *carbon* and *hydrogen*, *sulphur* and *phosphorus*, &c. We never find three different kinds of matter united together in any primary compound, provided it does not belong to the vegetable or animal kingdom. For primary compounds of organized matter contain usually three, and sometimes four, or even five or six, different kinds of substances; as *hydrogen*, *carbon*, and *oxygen*; *hydrogen*, *carbon*, *azote*, *oxygen*; *hydrogen*, *carbon*, *azote*, *iron*, *oxygen*; *hydrogen*, *carbon*, *azote*, *phosphorus*, *sulphur*, *oxygen*. According to Berzelius, one of the constituents of unorganized bodies always amounts only to 1 atom. This law certainly holds in the primary compounds. Whether it holds in those compounds called salts, is not so clear. We shall be better able to judge, when we have examined the composition of the salts in a subsequent part of this article.

In organic bodies, on the contrary, none of the constituents exists of necessity to the amount of 1 atom; though this may sometimes happen from accident. Hence the reasons of the very complex nature of organic bodies, and the numerous modifications of most of them that exist.

The *secondary* compounds, or those bodies formed by the union of primary compounds with each other, are of a much more complex nature. They frequently contain three or four different ingredients united together; as, for example, *alum*, *tartar emetic*, *Rochelle salt*. Now, as each of these constituents is composed of several atoms, it is obvious, that the composition of the secondary compounds is much more complicated than that of the primary compounds. It will be convenient, on that account, to consider each separately.

## II. Weight of the Atoms of the Simple Substances.

Before we can draw up a table of the relative weights of the simple substances, we must fix upon some one whose atom shall be represented by unity. Mr Dalton has made choice of hydrogen for this purpose, because it is the lightest of all known bodies. Sir Humphry Davy has followed his example; but he has doubled the weight of an atom of oxygen, and of most other bodies, by the arbitrary supposition, that water is composed of 2 atoms of hydrogen, and 1 atom of oxygen. Dr Wollaston, Professor Berzelius, and Dr Thomson, have adopted oxygen as the most convenient unit: nor can there be any hesitation in embracing their plans. Oxygen is, in fact, the substance by means of which the weights of the atoms of almost all other bodies are determined. It enters into a much greater number of combinations than any other known body. Hence, if we denote the weight of its atom by 1, a considerable convenience will result to the practical chemist. We shall exhibit the weights of the atoms of the simple bodies, under the form of tables, and we shall state at the bottom of each, the documents by means of which these weights were obtained.

### 1. *Simple Supporters.*

| Substances. | Weight of Atom. |
|---|---|
| 1 Oxygen - - | 1.000 |
| 2 Chlorine - - | 4.500 |
| 3 Iodine - - | 15.621 |

Oxygen having been chosen for the unit, we have already stated our reasons for the weight assigned. The weight is arbitrary, and adopted merely for the sake of convenience.

Chlorous oxide (the euchlorine of Davy) is composed of 2 volumes of chlorine gas, and 1 volume of

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oxygen gas. The specific gravity of chlorine gas is 2.483; that of oxygen gas 1.104. If we suppose chlorous acid to be composed of 1 atom chlorine, and 1 atom oxygen, a supposition which gives the simplest view of the composition of the chlorides, we have for the weight of an atom of chlorine this proportion, $1.104 : 4.966 :: 1 : 4.498 =$ the weight of an atom of chlorine.

The weight of an atom of iodine is the result of the experiments of Gay-Lussac, and may be considered as nearly correct. But we could not explain, in this place, the manner of conducting the experiments by which it was ascertained, without entering into details respecting the properties of this newly discovered substance that would be quite foreign to the present article.

### 2. *Simple Combustibles.*

| | Substances. | Weight of an Atom. |
|---|---|---|
| 4 | Hydrogen | 0.125 |
| 5 | Boron | 0.733 |
| 6 | Carbon | 0.750 |
| 7 | Phosphorus | 1.625 |
| 8 | Azote | 1.750 |
| 9 | Sulphur | 2.000 |
| 10 | Silicon | 2.000 |

The method of determining the weight of an atom of hydrogen has been explained in a preceding part of this article. It was there shown from the composition of water, that the weight of an atom of hydrogen is to that of an atom of oxygen as 1 to 7.56. Now, $7.56 : 1 :: 1 : 0.132 =$ weight of an atom of hydrogen. We have given 0.125 in the table, as the weight of an atom of hydrogen, because we consider it as established by a paper in the *Annals of Philosophy*, Vol. VI. p. 322, that the specific gravity of oxygen is 16 times that of hydrogen.

The experiments of Davy on the combustion of boron in oxygen gas, and those of Berzelius on the borates (*Annals of Philosophy*, Vol. III. p. 66.), have shown that boracic acid is composed of 100 oxygen + 36.649 boron. The resemblance between boron and carbon is so great, that it is very probable they will be analogous to each other in the proportion of oxygen with which they combine. Now, we shall see afterwards that carbonic acid is a compound of 1 atom carbon, and 2 atoms oxygen. Supposing boracic acid to be a compound of 1 atom boron, and 2 atoms oxygen, to determine the weight of an atom of boron, we have this proportion $\frac{100}{2} : 36.649 :: 1 : 0.733 =$ weight of an atom of boron.

When charcoal is burnt in oxygen gas, the bulk of the gas is not altered; it is merely converted into carbonic acid gas. Therefore, if we subtract the specific gravity of oxygen gas from that of carbonic acid gas, the remainder denotes the quantity of carbon in carbonic united with the weight of oxygen indicated by the specific gravity. Now,

| | Grains. |
|---|---|
| 100 cubic inches of carbonic acid weigh | 46.313 |
| 100 oxygen gas - | 33.672 |
| Remainder, - | 12.641 |

Therefore carbonic acid is composed of

| | | |
|---|---|---|
| Carbon - | 12.641 or | 27.29 |
| Oxygen - | 33.672 | 72.71 |
| | | 100. |

We shall see afterwards that carbonic acid is composed of 1 atom carbon + 2 atoms oxygen. Therefore, to find the weight of an atom of carbon, we have this proportion, $\frac{72.71}{2} : 27.29 :: 1 : 0.751 =$ weight of an atom of carbon.

The writer of this article has ascertained, by experiments which it would be too tedious to adduce here, that phosphoric acid is composed of 100 phosphorus + 123 oxygen, and that it consists of 1 atom phosphorus + 2 atoms oxygen. Hence the weight of an atom of phosphorus is 1.625.

The determination of the weight of an atom of azote is attended with considerable difficulty. We have no doubt, that it is in reality a compound. But whether it consists of hydrogen united to oxygen, as is the opinion of Mr Miers, or of nitricum and oxygen, as Berzelius believes, has not yet been decided by satisfactory experiments. We must, therefore, in the present state of our knowledge, allow it a place among the undecomposed bodies. It scarcely belongs to the combustibles, as it does not in any case exhibit the phenomena of combustions. But we give it a place among them for want of any better situation under which it could be arranged. Azote combines with four proportions of oxygen, and constitutes four compounds, all of which have been analyzed with care. If we denominate the quantity of oxygen that unites with 100 parts of azote by $x$, the following table will exhibit the constituents of these compounds.

| | |
|---|---|
| Nitrous oxide . | 100 azote + 1 $x$ |
| Nitrous gas . . | 100 azote + 2 $x$ |
| Nitrous acid . . | 100 azote + 3 $x$ |
| Nitric acid . . | 100 azote + 5 $x$ |

From this table there can be no doubt, that $x$ represents an atom of oxygen. Hence we have only to ascertain the value of $x$, to be able to determine the weight of an atom of azote. Now nitrous oxide, nitrous gas, and nitric acid, have been analyzed with care, and the number in the table is the mean resulting from these analyses.

It has been ascertained by many and careful experiments, that sulphurous and sulphuric acids are composed as follows:

Sulphur.

| | | |
|---|---|---|
| Sulphurous acid . | 100 + | 100 oxygen. |
| Sulphuric acid . . | 100 | 150 |

Hence we see, that the first contains two atoms of oxygen, and the second three atoms of oxygen, combined each with one atom of sulphur. Therefore for the weight of an atom of sulphur, we have this proportion $\frac{100}{2}:100::1:2=$ weight of an atom of sulphur.

The atom of silicon, which is a combustible substance analogous to charcoal, the base of the earth called silica, is derived from the experiments of Berzelius, for which we refer to his *mineralogical essay*, lately translated into English, as it would not be possible to make these experiments intelligible here, without entering into details, quite inconsistent with the nature of this article. These details will probably find a place under the article CHEMISTRY, to which therefore we refer the reader.

3. *Metals.*

| | | Weight of an Atom. |
|---|---|---|
| 11 | Aluminum | 1.125 |
| 12 | Ammonium | 1.125 |
| 13 | Magnesium | 1.500 |
| 14 | Calcium | 2.625 |
| 15 | Tellurium | 4.027 |
| 16 | Zinc | 4.095 |
| 17 | Zirconium | 4.625 |
| 18 | Chromium | 4.750 |
| 19 | Potassium | 5.000 |
| 20 | Arsenic | 6.000 |
| 21 | Sodium | 5.875 |
| 22 | Strontium | 5.500 |
| 23 | Molybdenum | 6.013 |
| 24 | Glucinum | 6.833 |
| 25 | Manganese | 7.125 |
| 26 | Iron | 7.143 |
| 27 | Nickel | 7.305 |
| 28 | Cobalt | 7.326 |
| 29 | Yttrium | 7.375 |
| 30 | Copper | 8.000 |
| 31 | Barytium | 8.750 |
| 32 | Bismuth | 9.000 |
| 33 | Antimony | 11.250 |
| 34 | Cerium | 11.500 |
| 35 | Uranium | 12.000 |
| 36 | Tungsten | 12.125 |
| 37 | Platinum | 12.125 |
| 38 | Silver | 13.750 |
| 39 | Palladium | 14.075 |
| 40 | Tin | 14.750 |
| 41 | Rhodium | 15.000 |
| 42 | Titanium | 18.000 |
| 43 | Gold | 24.875 |
| 44 | Mercury | 25.000 |
| 45 | Lead | 26.000 |

In the preceding table we have been obliged to omit the weight of an atom of three metals, namely, osmium, iridium, and columbium, because we are at present unacquainted with the analyses of their oxides, and of all the compounds which they form. The weights of the atoms of the metals inserted, have been taken from the best documents at present in possession of chemists. But we are far from supposing that they are all correct. Some have little better than analogical reasoning in their favour, while the weight of others is founded upon a law discovered by Berzelius relative to the salts; namely, that the oxygen in the acid of a neutral salt, is always a multiple of the oxygen in the base, by 2, 3, 4, 5, &c. and this number is always constant for every particular acid.

The weight of an atom of aluminum is calculated from the composition of alum. This salt is a combination of sulphate of potash and sulphate of alumina. Sulphuric acid is saturated by a quantity of base containing one third of the oxygen in the acid. Knowing the analysis of the salt, we obtain from this law the quantity of oxygen in a given weight of alumina. If we suppose alumina a compound of 1 atom aluminum, and 1 atom oxygen, the weight of an atom of aluminum will be as in the table. This hypothesis, however, is quite arbitrary. But it seems better to be satisfied with it at present, because we are not in possession of any data to enable us to reason on the subject. The weight of the atoms of the bases of the alkaline earths, and earths proper, were ascertained by a similar process of reasoning. They are smaller than the weights of those atoms assigned by Berzelius, because he conceives them to be united with more than one atom of oxygen. We have given, however, in the table, the weight of an atom of glucinum, as determined by Berzelius in a set of new experiments, which he has published as an appendix to his treatise on mineralogy, above referred to. The weights of the atom of potassium and sodium, are obtained from the experiments of Davy, and Gay-Lussac, and Thenard. It appears that potash is a compound of 100 potassium, and 20 oxygen, and peroxide of potassium of 100 potassium, and 60 oxygen. Hence the weight of an atom of potassium is obvious. Soda is composed of 100 sodium and 34.1 oxygen; peroxide of sodium of 100 sodium, and 51.1. Now 34.1 is to 51.1 as 2:3. Hence soda must contain 2 atoms of oxygen. For its weight therefore we have this proportion $\frac{34.1}{2}:100::1:5.882=$ weight of an atom of sodium.

Ammonium is a problematic substance which never yet has been obtained in a separate state. But when a globule of mercury is moistened with ammonia, and acted on by a galvanic battery, the mercury is converted into an amalgam of the consistence of butter, and not the fourth part of its original specific gravity. This fact cannot be explained any other way than by supposing ammonia to be a compound of oxygen, and an unknown metallic base which amalgamates with the mercury in the galvanic experiment. Analogy comes strongly in favour of this opinion. We are acquainted with nearly fifty bases which have the property of neutralizing acids, of which ammonia is one. Now it is known, that all the rest contain oxygen as a constituent. Hence, it would be singular if ammonia alone, of all

the bases, should constitute an exception to a general rule. There seems to be little doubt, that sal-ammoniac is a compound of chlorine and ammonium. This salt is formed by the union of equal volumes of muriatic acid gas, and ammoniacal gas. Hence, it consists of

| | |
|---|---|
| Muriatic acid - - | 100 |
| Ammonia - - - | 46.178 |
| By weight - - | 146.178 |

Now, muriatic acid is a compound of 75.731 chlorine, and 2.23 hydrogen. Therefore, 100 muriatic acid contain 2.86 hydrogen. We must suppose this hydrogen to find in the ammonia a quantity of oxygen capable of converting it into water. Now, 2.86 hydrogen require $21\frac{2}{3}$ oxygen to convert them into water. Therefore ammonia must be a compound of

| | | |
|---|---|---|
| Ammonium | 24.511 | or 100. |
| Oxygen . . | 21.666 | 88.39. |

Now, if ammonia be composed of 1 atom oxygen, and 1 atom ammonium, we have, for finding the weight of an atom of ammonium, this proportion :— $21.666 : 24.511 :: 1 : 1.149 =$ weight of an atom of ammonium.

The weight of an atom of zinc is founded on Dr Thomson's analysis of Blende (*Annals of Philosophy*, IV. 89). It agrees almost exactly with the analysis of oxide of zinc by Berzelius. But Berzelius doubles the weight of an atom of zinc, by supposing the existence of another oxide, containing less oxygen than the white oxide. But as this oxide has never been obtained nor examined by any one, we have no right to suppose its existence. The weight of an atom of tellurium is derived from the experiments of Berzelius. Its oxide, according to him, is composed of 100 tellurium + 24.83 oxygen.

Berzelius (*Annals of Philosophy*, III. 101.) has shown that there are three oxides of chromium, the green, the brown, and chromic acid. The first contains 100 metal + 42.37 oxygen, while the acid is composed of 100 metal + 84.74 oxygen. These numbers are to each other as 1 to 2. As the brown oxide is intermediate, we must suppose the green oxide a compound of 1 atom metal + 2 atoms oxygen ; the brown of 1 atom metal + 3 oxygen ; and the acid of 1 atom metal + 4 atoms oxygen. This gives us the weight of an atom of chromium, stated in the table. But it would not be surprising if the brown oxide were merely a mixture or combination of the green oxide and chronic acid. On that supposition the weight of an atom of chromium would be only 2.375.

Berzelius has published an elaborate set of experiments on arsenic (*Annals of Philosophy*, III. 93.), in which he endeavours to prove that there are four oxides of arsenic, namely, 1. The black oxide, composed of 1 atom metal + 1 atom oxygen. 2. Salipable oxide of arsenic, composed of 1 atom metal + 3 atoms oxygen. 3. Arsenious acid, composed of 1 atom metal + 4 atoms oxygen ; and, 4. Arsenic acid, composed of 1 atom metal + 6 atoms oxygen. But his experiments are too complicated, and his reasoning too hypothetical, to produce conviction ; especially as they appear inconsistent with the much simpler experiments of Proust, Thenard, Rose, Bucholz, and Thomson, from which it appears that 100 arsenic, when converted into arsenic acid, becomes 152.4. It was from this experiment of Dr Thomson that the weight of an atom of arsenic in the table was derived.

The weight of an atom of molybdenum is deduced from the experiments of Bucholz. He found two oxides of molybdenum, the blue and the white, composed of 100 metal united with 34 and 50 oxygen. Now 34 is to 50 as 2 to 3. Hence the first is a deutoxide, and we have for the weight of molybdenum this proportion $\frac{34}{2} : 100 :: 1 : 6.013 =$ weight of an atom of molybdenum.

There are four oxides of manganese, the green, the olive, the brown, and the black. The composition of these oxides is as follows :

| | | |
|---|---|---|
| 1st oxide composed of | 100 metal | + 14.0533 oxygen. |
| 2d oxide | 100 | + 28.107. |
| 3d oxide | 100 | + 42.16. |
| 4th oxide | 100 | + 56.213. |

Now, the quantities of oxygen in these oxides are to each other as the numbers 1, 2, 3, 4. Hence the first is a protoxide ; and for the weight of an atom of manganese we have this proportion $14.0533 : 100 :: 1 : 6.833 =$ weight of an atom of manganese.

Iron forms two oxides, the black and the red. The first of these, according to the experiments of Dr Thomson, is composed of 100 metal + 28 oxygen, the second of 100 metal + 42 oxygen. Now 28 is to 42 as 2 to 3. Hence $\frac{28}{2} : 100 :: 1 : 7.143 =$ weight of an atom of iron.

Nickel and cobalt agree with iron in being magnetic. They agree, likewise, in the number of oxides which they form, and almost in the proportion of oxygen with which they unite. Probably future experiments will show these proportions to be absolutely identical. At present it is believed, that the two oxides of nickel are composed as follows :

| | | |
|---|---|---|
| 1st oxide | 100 nickel | + 27.6 oxygen. |
| 2d oxide | 100 | + 41. |

while those of cobalt consist of

| | | |
|---|---|---|
| 1st oxide | 100 cobalt | + 27.3 oxygen. |
| 2d oxide | 100 | + 40.95. |

These slight differences in the proportion of oxygen occasion the difference between the weights of the atoms of these metals and that of iron.

There are two oxides of copper, the red and the black, composed of

1st oxide 100 metal + 12.5 oxygen.
2d oxide 100 + 25.

Hence 12.5 : 100 :: 1 : 8 = weight of an atom of copper.

Bismuth forms only one oxide. A mean of the experiments of Thomson, Lagerhjelm, and John Davy, gives its composition 100 metal + 11.229. Hence the number in the table.

There is no metal so difficult to experiment on as antimony. Hence, notwithstanding the laborious efforts of many distinguished chemists, considerable uncertainty still exists, both respecting the number and the composition of its various oxides. Proust makes only two oxides of antimony: Thenard makes six, and Berzelius makes four. We think it safer, in the present state of our knowledge, to deduce the weight of an atom of antimony from the sulphuret, which can be analyzed with accuracy, than from the oxides, respecting the constitution of which considerable doubts still remain. From the experiments of Dr Thomson (*Annals of Philosophy*, IV. 99.), it appears that sulphuret of antimony is composed of 100 metal + 35.556 sulphur. Now, supposing it a compound of 1 atom metal + 2 atoms sulphur, an atom of antimony will weigh 11.249.

The weight of an atom of cerium is founded on the experiments of Hisinger, which may be seen in the *Annals of Philosophy*, IV. 355.

Bucholz has shown that there are two oxides of uranium, the black and the yellow; the first composed of 100 metal + 8.333 oxygen, the second of 100 metal + 25 oxygen. These numbers are to each other as 1 to 3. Hence 8.333 : 100 :: 1 : 12 = weight of an atom of uranium.

Berzelius has shown (*Annals of Philosophy*, III. 244), that there are two oxides of tungsten, brown oxide, and tungstic acid. The first is composed of 100 metal + 16.5 oxygen, the second of 100 metal + 24.75 oxygen. Now 16.5 is to 24.75 as 2 to 3. Therefore $\frac{16.5}{2}$ : 100 :: 1 : 12 : 121 = weight of an oxide of tungsten.

Berzelius obtained two oxides of platinum. The first composed of 100 metal + 8.287 oxygen, the second of 100 metal + 16.36. Now 8.287 is to 16.36 as 1 to 2. Therefore 8.287 : 100 :: 1 : 12.161 = weight of an atom of platinum.

Silver forms only one oxide, and it parts with its oxygen so easily, that it is very difficult to determine the proportion of oxygen with which it unites. The number in the table is derived from horn-silver, which is known to be a compound of 100 chlorine and 304.89 silver. This gives us the weight of an atom of silver 13.714, and the oxide of silver, a compound of 100 silver + 7.291 oxygen.

Berzelius could form only one oxide of palladium. It was brown, and composed of 100 metal + 14.209 oxygen. If we suppose this a deutoxide, which is probable, then we have $\frac{14.209}{2}$ : 100 :: 1 : 14.075 = weight of an atom of palladium.

Proust first proved that tin forms three oxides. According to Berzelius, the first oxide is composed of 100 metal + 13.6 oxygen, and the peroxide of 100 metal + 27.2. As there is an intermediate oxide, we cannot avoid concluding that the first oxide is a compound of 1 atom metal + 2 atoms oxygen. For the oxygen in the peroxide is just double that in the first oxide. Therefore for an atom of tin we have this proportion, $\frac{13.6}{2}$ : 100 :: 1 : 14.705 = weight of an atom of tin.

Berzelius has shown that there are three oxides of rhodium. The first, constituting the base of the muriate, is composed of 100 metal + 6.71 oxygen. The second of a flea brown colour, obtained by heat, is composed of 100 metal + 13.42 oxygen. The third is red, and is obtained by precipitation from the soda-muriate. It contains more oxygen than either of the other two (*Annals of Philosophy*, III. 252.). We have therefore 6.71 : 100 :: 1 : 14.903 = weight of an atom of rhodium.

The weight of an atom of titanium, given in the table, is not much to be depended on. It is the number given by Berzelius from an experiment of Richter (*Annals of Philosophy*, III. 251.), and is merely inserted for want of better data.

To the indefatigable industry and address of Berzelius, we are indebted for our knowledge of the composition of the oxides of gold. His mode of proceeding was not quite beyond the reach of objection, though perhaps, upon the whole, the best that he could have had recourse to, with the prospect of an answer to the problem which he was investigating. A determinate quantity of gold was dissolved in nitromuriatic acid, and thus converted into yellow oxide or peroxide of gold. He ascertained how much mercury was necessary to precipitate this gold in the metallic state. This portion of mercury united with all the oxygen of the gold. Now, as the composition of oxide of mercury is known, it was easy to determine how much oxygen had been united with the gold. By exposing the muriate of gold to heat, its nature was altered, and another oxide of gold formed, containing less oxygen. When water is poured upon this substance, two-thirds of the gold are reduced, and the other third converted into yellow oxide. Hence this new oxide contained only the third part of the oxygen in the yellow oxide. The yellow oxide was composed of 100 gold + 12.077 oxygen. Hence, the protoxide consisted of 100 gold + 4.026 oxygen. Now 4.026 : 100 :: 1 : 24.838 = weight of an atom of gold.

The weight of an atom of mercury, is taken from the experiments of Thenard, and Fourcroy, and Sefstrom. The mean of these give us black oxide of mercury, composed of 100 mercury + 4 oxygen, and red oxide of 100 mercury + 8 oxygen.

There are three oxides of lead, the yellow, the red, and the brown; the first composed of 100 metal + 7.7 oxygen, the second of 100 metal + 11.55 oxygen, and the third of 100 metal + 15.4 oxygen. Now 7.7, 11.55, and 15.4, are to each other as the numbers 2, 3, 4. Therefore, the yellow oxide con-

tains two atoms of oxygen, and we have $\frac{7.7}{2}$ : 100 : : 1 : 25.974 = weight of an atom of lead.

Such are the weights of the atoms of the simple substances, and such the documents upon which these weights are founded. The importance of these weights will best appear by giving a view of the compounds which these bodies form with each other.

### III. Weight of the Integrant Particles of Primary Compounds.

The primary compounds being very numerous, we shall, for the sake of distinctness, subdivide them under different heads.

1. *Compounds of the Simple Combustibles with Oxygen.*

| Substances. | Number of Atoms. | Weight of an Integrant Particle. |
|---|---|---|
| 46 Water | 1*h* + 1*o* | 1·125 |
| 47 Boracic acid | 1*b* + 2*o* | 2·733 |
| 48 Carbonic oxide | 1*c* + 1*o* | 1·750 |
| 49 Carbonic acid | 1*c* + 2*o* | 2·750 |
| 50 Phosphorous acid | 1*p* + 1*o* | 2·625 |
| 51 Phosphoric acid | 1*p* + 2*o* | 3·625 |
| 52 Nitrous oxide | 1*a* + 1*o* | 2·750 |
| 53 Nitrous gas | 1*a* + 2*o* | 3·750 |
| 54 Nitrous acid | 1*a* + 3*o* | 4·750 |
| 55 Nitric acid | 1*a* + 5*o* | 6·750 |
| 56 Sulphurous acid | 1*s* + 2*o* | 4·000 |
| 57 Sulphuric acid | 1*s* + 3*o* | 5·000 |
| 58 Silica | 1*s* + 2*o* | 6·000 |

Water is composed of two measures of hydrogen gas, united to one measure of oxygen. The reasons for considering it as a compound of 1 atom hydrogen, and 1 atom oxygen, have been already stated.

Boracic acid is conceived to contain two atoms of oxygen, because this is the case with carbonic acid, and the analogy between carbon and boron is very striking.

If 100 measures of carbonic oxide be mixed with 50 measures of oxygen gas, and the mixture be fired by electricity, the result will be 100 measures of carbonic acid. If charcoal be burnt on 100 measures of oxygen gas, the bulk is not altered, but the oxygen is changed into carbonic acid. From these facts, it is obvious that the oxygen in carbonic oxide, combined with a given quantity of carbon, is just half of that in carbonic acid combined with the same quantity of carbon. Hence the first must be a compound of 1 atom carbon + 1 atom oxygen; the second of 1 atom carbon + 2 atoms oxygen. The weights in the table correspond exactly with the analysis of these two substances.

Several of the compounds of azote and oxygen have been analyzed with great care; namely, nitrous oxide, nitrous gas, and nitric acid; and the results coincide with the numbers given in the table. Nitrous acid is merely given from theory. It has not hitherto been possible to analyze it.

Sulphurous acid was first analyzed by Dr Thomson, who showed that it contained two-thirds of the oxygen in sulphuric acid. It seems demonstrated by the experiments of Klaproth, Berzelius, &c. that sulphuric acid is a compound of 100 sulphur + 150 oxygen. Therefore sulphurous acid must be composed of 100 sulphur + 100 oxygen, and the composition of both must be as in the table.

The composition of silica is taken from the experiments and calculations of Berzelius, and depends chiefly upon analogical reasoning.

2. *Compounds of the Simple Combustibles with each other.*

| | Number of Atoms. | Weight of an Integrant Particle. |
|---|---|---|
| 59 Olefiant gas | 1*c* + 1*h* | 0.875 |
| 60 Carbureted hydrogen | 1*c* + 2*h* | 1.000 |
| 61 Hydrophosphoric gas | 1*p* + 2*h* | 1.875 |
| 62 Phosphureted hydrogen | 1*p* + 4*h* | 2.125 |
| 63 Ammonia | 1*a* + 3*h* | 2.125 |
| 64 Sulphureted hydrogen | 1*s* + 1*h* | 2.125 |
| 65 Sulphuret of carbon | 1*c* + 2*s* | 4.750 |

Olefiant gas requires for complete combustion three times its bulk of oxygen gas, and forms twice its bulk of carbonic oxide; carbureted hydrogen requires twice its bulk of oxygen, and forms its own bulk of carbonic acid. Hence, it is obvious, that supposing the quantity of hydrogen the same in both, the carbon in olefiant gas, is just double that in carbureted hydrogen. We might have conceived carbureted hydrogen to be a compound of 1 atom hydrogen, and 1 atom carbon, and olefiant gas of 1 atom hydrogen, and 2 atoms carbon. But the reasons assigned by Mr Dalton, have induced us to adopt the composition in the table, which comes in fact to the very same thing.

The two gases which are composed of phosphorus and hydrogen, have not been hitherto analyzed. But it appears from Davy that the specific gravity of the first is double that of the second. Davy states his hydrophosphoric gas to be composed of 100 hydrogen by weight, and 489.56 phosphorus. The numbers in the table are founded on these data; though they do not quite correspond.

Ammonia, by electricity, may be resolved into 3 measures of hydrogen, and 1 measure of azote. 300 cubic inches of hydrogen gas weigh 6.69 grains, and 100 cubic inches of azotic gas weigh 29.56 grains. Now 6.69 : 29.56 : : 0.132 × 3 : 1.704 = weight of an atom of azote very nearly.

We have given the data upon which the composition of sulphureted hydrogen is founded in a preceding part of this article. It is therefore unnecessary to repeat them here.

Sulphuret of carbon was analyzed by Berzelius and Marcet, who found it a compound of 84.83 sulphur. and 15.17 carbon. The composition of this substance, as given in the table, supposes it a compound of 84.2 sulphur + 15.8 carbon; numbers which may be considered as identical with the preceding, since the difference is within the limits of the unavoidable errors of experiment.

*3. Metallic Oxides.*

| | Oxides. | Number of Atoms. | Weight of an Integrant Particle. |
|---|---|---|---|
| 66 | Alumina - | 1 *a* + 1 *o* | 2.125 |
| 67 | Ammonia - - | 1 *a* + 1 *o* | 2.125 |
| 68 | Magnesia - - | 1 *m* + 1 *o* | 2.500 |
| 69 | Lime - - - | 1 *c* + 1 *o* | 3.625 |
| 70 | Oxide of tellurium - | 1 *t* + 1 *o* | 5.027 |
| 71 | Oxide of zinc - | 1 *z* + 1 *o* | 5.095 |
| 72 | Zirconia - - | 1 *zir* + 1 *o* | 5.625 |
| 73 | Green oxide of chromium | 1 *ch* + 2 *o* | 6.750 |
| 74 | Brown oxide of chromium | 1 *ch* + 3 *o* | 7.750 |
| 75 | Chromic acid - | 1 *ch* + 4 *o* | 8.750 |
| 76 | Potash - - | 1 *p* + 1 *o* | 6.000 |
| 77 | Peroxide of potassium | 1 *p* + 2 *o* | 7.000 |
| 78 | Arsenious acid - | 1 *ars* + 2 *o* | 8.000 |
| 79 | Arsenic acid - | 1 *ars* + 3 *o* | 9.000 |
| 80 | Soda - - - | 1 *sod* + 2 *o* | 7.875 |
| 81 | Peroxide of sodium | 1 *sod* + 3 *o* | 8.875 |
| 82 | Strontian - | 1 *str* + 1 *o* | 6.500 |
| 83 | Deutoxide of molybdenum | 1 *m* + 2 *o* | 8.013 |
| 84 | Peroxide of molybdenum | 1 *m* + 3 *o* | 9.013 |
| 85 | Glucina - - | 1 *gl* + 3 *o* | 9.833 |
| 86 | Protoxide of manganese | 1 *m* + 1 *o* | 7.125 |
| 87 | Deutoxide of manganese | 1 *m* + 2 *o* | 8.125 |
| 88 | Tritoxide of manganese | 1 *m* + 3 *o* | 9.125 |
| 89 | Peroxide of manganese | 1 *m* + 4 *o* | 10.125 |
| 90 | Deutoxide of iron - | 1 *i* + 2 *o* | 9.143 |
| 91 | Peroxide of iron - | 1 *i* + 3 *o* | 10.143 |
| 92 | Deutoxide of nickel | 1 *n* + 2 *o* | 9.305 |
| 93 | Peroxide of nickel | 1 *n* + 3 *o* | 10.305 |
| 94 | Deutoxide of cobalt | 1 *c* + 2 *o* | 9.326 |
| 95 | Peroxide of cobalt | 1 *c* + 3 *o* | 10.326 |
| 96 | Yttria - - | 1 *y* + 1 *o* | 8.375 |
| 97 | Protoxide of copper | 1 *c* + 1 *o* | 9.000 |
| 98 | Peroxide of copper | 1 *c* + 2 *o* | 10.000 |
| 99 | Barytes - - | 1 *b* + 1 *o* | 9.750 |
| 100 | Oxide of bismuth - | 1 *b* + 1 *o* | 10.000 |
| 101 | Deutoxide of antimony | 1 *a* + 2 *o* | 13.250 |
| 102 | Tritoxide of antimony | 1 *a* + 3 *o* | 14.250 |
| 103 | Peroxide of antimony | 1 *a* + 4 *o* | 15.250 |
| 104 | Deutoxide of cerium | 1 *c* + 2 *o* | 13.500 |
| 105 | Peroxide of cerium | 1 *c* + 3 *o* | 14.500 |
| 106 | Protoxide of uranium | 1 *u* + 1 *o* | 13.000 |
| 107 | Peroxide of uranium | 1 *u* + 3 *o* | 15.000 |
| 108 | Deutoxide of tungsten | 1 *t* + 2 *o* | 14.125 |
| 109 | Peroxide of tungsten | 1 *t* + 3 *o* | 15.125 |
| 110 | Protoxide of platinum | 1 *p* + 1 *o* | 13.125 |
| 111 | Peroxide of platinum | 1 *p* + 2 *o* | 14.125 |
| 112 | Oxide of silver - | 1 *s* + 1 *o* | 14.750 |
| 113 | Peroxide of palladium | 1 *p* + 2 *o* | 16.075 |
| 114 | Deutoxide of tin - | 1 *t* + 2 *o* | 16.750 |
| 115 | Tritoxide of tin - | 1 *t* + 3 *o* | 17.750 |
| 116 | Peroxide of tin - | 1 *t* + 4 *o* | 18.750 |
| 117 | Protoxide of rhodium | 1 *rh* + 1 *o* | 16.000 |
| 118 | Protoxide of rhodium | 1 *rh* + 2 *o* | 17.000 |
| 119 | Peroxide of rhodium | 1 *rh* + 3 *o* | 18.000 |
| 120 | Protoxide of titanium | 1 *t* + 1 *o* | 19.000 |
| 121 | Peroxide of titanium | 1 *t* + 2 *o* | 20.000 |
| 122 | Protoxide of gold | 1 *g* + 1 *o* | 25.875 |
| 123 | Peroxide of gold - | 1 *g* + 3 *o* | 27.875 |
| 124 | Protoxide of mercury | 1 *m* + 1 *o* | 26.000 |
| 125 | Peroxide of mercury | 1 *m* + 2 *o* | 27.000 |
| 126 | Deutoxide of lead - | 1 *l* + 2 *o* | 28.000 |
| 127 | Tritoxide of lead - | 1 *l* + 3 *o* | 29.000 |
| 128 | Peroxide of lead - | 1 *l* + 4 *o* | 30.000 |

This table contains all the metallic oxides at present known, which are 62 in number. We have omitted a few which Thenard has admitted into his *System of Chemistry*, just published; but which do not seem to be supported by sufficiently strong evidence, to induce us to admit their existence. The same remark applies to some of the oxides of Gay-Lussac and Thenard; and, perhaps, also to some of the oxides of Berzelius. In short, we have admitted no primary compound into our tables, the existence of which is not demonstrated by the clearest evidence. For the loose admission of hypothetical bodies seems to us injurious, rather than beneficial to the progress of the science.

Alumina, Magnesia, Lime, Zirconia, Strontian, Yttria, Barytes, are supposed compounds of 1 atom base, and 1 atom oxygen; because we do not know any other compounds which these bases form with oxygen; and, therefore, have no data to reason on the subject. Their composition has been calculated from the composition of the sulphates of alumina, magnesia, lime, zirconia, strontian, yttria, barytes, the constitution of which will be shown in a subsequent part of this article. The calculation was made, on the supposition, that the quantity of each base which saturates a given weight of sulphuric acid, contains just one-third of the oxygen in the acid: a law which holds, in every case, in which we have it in our power to verify it.

Ammonia, in the present state of the sciences, is an ænigmatical substance. We have given before a view of its composition, on the supposition, that it is a compound of hydrogen and azote. Here, its composition is seen on the supposition that it is a compound of ammonium and oxygen. Both analyses seem demonstrated. The seeming inconsistency will vanish, whenever it can be shown that azote is a compound of hydrogen and oxygen.

Potash, peroxide of potash, soda, peroxide of soda, are given according to the experiments of Davy, and Gay-Lussac, and Thenard. The French chemists admit an oxide of potassium and sodium, containing each less oxygen than exists in potash and soda. But the existence of these supposed oxides is not made out in a satisfactory manner. For any thing that appears to the contrary, their oxides may be mixtures of potash and potassium, soda and sodium.

In stating the weights of the atoms of the metals, we have noticed the most accurate experiments hitherto made, to determine the number and composition of the different metallic oxides; and it does not seem necessary to resume the subject here. If the reader be at the trouble to make the trial, he will find, that the numbers in the table agree very correctly with the best results of the analysis of the metallic oxides hitherto obtained. Hence there can be no doubt, that at least a considerable part of the table is accurate.

### 4. *Combinations of the Metals and Simple Combustibles.*

(1) *Hydrurets.*

| | | Number of Atoms. | Weight of an Integrant Particle. |
|---|---|---|---|
| 129 | Arsenical hydrogen gas | 1 *a* + 9 *h* | 7.125 |
| 130 | Tellurated hydrogen gas | unknown | |
| 131 | Potassurated hydrogen gas | unknown | |

From the experiments of Gay-Lussac and Thenard, it appears, that 100 measures of arsenical hydrogen gas, when deprived of its arsenic, by heating tin in it, expand and become 140 measures. Sir Humphry Davy found this gas 8 times heavier than hydrogen. Trommsdorf found it 0.529, that of common air being 1.000, which is only a very little lighter than Davy's statement. These data give us its composition, 9 atoms hydrogen, and 1 atom arsenic. But it is not unlikely, that part of the hydrogen was only mechanically mixed. From the experiments of Ritter, confirmed by Davy, and Gay-Lussac, and Thenard, it appears, that there exists a solid hydruret of arsenic, which may be formed by attaching slips of arsenic to the negative pole of a galvanic battery, dipping the arsenic in water, and completing the circuit. It is a brown flocky substance, which has not been analyzed. It seems to be more fixed in the fire than arsenic itself.

Telluretted hydrogen gas has not yet been analyzed. Its properties are similar to those of sulphurated hydrogen. Hence analogy would lead us to suppose that its composition is similar. In that case, it would be composed of 1 atom tellurium, and 1 atom hydrogen, and the weight of an integrant particle of it would be 4.152.

(2.) *Sulphurets.*

| | | Number of Atoms. | Weight of an Integrant Particle. |
|---|---|---|---|
| 132 | Sulphuret of zinc | 1 *z* + 1 *s* | 6.095 |
| 133 | Sulphuret of tellurium | 1 *t* + 2 *s* | 8·027 |
| 134 | Sulphuret of potassium | 1 *p* + 1 *s* | 7.000 |
| 135 | Sulphuret of arsenic | 1 *a* + 2 *s* | 10.000 |
| 136 | Sulphuret of sodium | 1 *sod.* + 2 *s* | 9.875 |
| 137 | Sulphuret of molybdenum | 1 *m* + 2 *s* | 10.013 |
| 138 | Sulphuret of manganese | 1 *m* + 1 *s* | 9.125 |
| 139 | Prosulphuret of iron | 1 *i* + 2 *s* | 11.143 |
| 140 | Persulphuret of iron | 1 *i* + 4 *s* | 15.143 |
| 141 | Sulphuret of nickel | 1 *n* + 2 *s* | 11.305 |
| 142 | Sulphuret of cobalt | 1 *c* + 2 *s* | 11.326 |
| 143 | Sulphuret of copper | 1 *c* + 1 *s* | 10.000 |
| 144 | Sulphuret of bismuth | 1 *b* + 1 *s* | 11.000 |
| 145 | Sulphuret of antimony | 1 *a* + 2 *s* | 15.250 |
| 146 | Sulphuret of platinum | 1 *p* + 2 *s* | 16.125 |
| 147 | Sulphuret of silver | 1 *sil.* + 1 *s* | 15.750 |
| 148 | Sulphuret of palladium | 1 *p* + 1 *s* | 16.075 |
| 149 | Prosulphuret of tin | 1 *t* + 1 *s* | 16.750 |
| 150 | Persulphuret of tin | 1 *t* + 2 *s* | 18.750 |
| 151 | Sulphuret of gold | 1 *g* + 3 *s* | 30.875 |
| 152 | Prosulphuret of mercury | 1 *m* + 1 *s* | 27.000 |
| 153 | Persulphuret of mercury | 1 *m* + 2 *s* | 29.000 |
| 154 | Prosulphuret of lead | 1 *l* + 2 *s* | 30.000 |
| 155 | Persulphuret of lead | 1 *l* + 4 *s* | 34.000 |

According to the experiments of Dr Thomson (*Annals of Philosophy*, IV. 94.), sulphuret of zinc is composed of 100 metal + 48.84 sulphur. Hence the numbers in the table which have been derived from that analysis.

The composition of sulphuret of tellurium is derived from an experiment of Davy. He found, that tellurium united by fusion with nearly its own weight of sulphur. Hence it ought to combine with two atoms. Analogy, however, is against this conclusion. In all other cases, when a metal forms only one oxide, its sulphuret contains only one atom of sulphur. Hence the composition of sulphuret of tellurium, as stated in the table, is very doubtful.

The composition of sulphuret of potassium is derived from the experiments of Davy. Sulphuret of sodium is stated from the following analogy, having never been analyzed. Berzelius has shown, that all the sulphurets, when treated with nitric acid, are converted into neutral sulphates, without any redundancy of acid or base. Therefore, sulphuret of sodium, by this treatment, would be converted into sulphate of soda. But sulphate of soda is composed of 2 integrant particles of sulphuric acid, and 1 integrant particle of soda. Therefore, sulphuret of sodium must be composed of 2 atoms sulphur, and 1 atom sodium.

From the experiments of Laugier it appears, that sulphuret of arsenic is composed of 42 sulphur + 58 arsenic. According to him, it is often mixed with an excess of arsenic, which occasions the apparent variableness in its composition. The experiments of Proust and Thenard do not agree well with those of Laugier. Hence the subject cannot be considered as completely cleared up.

Sulphuret of manganese is derived from an experiment of Vauquelin, who found that 74.8 manganese united with 25.5 of sulphur by heat.

Bucholz found sulphuret of molybdenum composed of 60 molybdenum + 40 sulphur. Hence its constitution as stated in the table.

The two sulphurets of iron were first analyzed by Hatchett, and the table is conformable to the results of that analysis. We consider the late speculations of Stromeyer on magnetic pysites as erroneous.

Nickel and cobalt have so close an analogy to iron in their combinations, that it is reasonable to expect that the sulphurets will also correspond. Hence the reason for considering these sulphurets as compounds of one atom metal and two atoms sulphur. This statement likewise approaches nearest to the results obtained by Proust.

It has been ascertained that 100 copper combine with 25 sulphur. This coincides exactly with the statement in the table.

John Davy has shown that 67.5 bismuth unite with 15.08 sulphur. Lagerhjelm found that 100 bismuth unite with 22.52 sulphur. Both of these statements coincide sufficiently with the table.

From the analysis of sulphuret of antimony by Dr Thomson (*Annals of Philosophy*, IV. 99.), we learn, that it is a compound of 100 metal + 35.556 sulphur. With this analysis the statement in the table exactly coincides.

Atomic Theory.

Berzelius informs us, that 100 platinum combine with 32.8 sulphur. Now 108 : 32.8 : : 12.161 : 3.938 = 2 atoms of sulphur very nearly.

According to Berzelius, 100 sulphur combine with 14.9 sulphur. Now 100 : 14.9 : : 13.714 : 2.0434 = an atom of sulphur very nearly.

Sulphuret of palladium has not been analyzed; but, as palladium forms only one oxide, we may, without much risk of error, consider the sulphuret as a compound of 1 atom metal and 1 atom sulphur.

From the experiments of Dr Davy it appears, that mosaic gold contains just double the quantity of sulphuret in common sulphuret of tin. According to the experiments of the same chemist, protosulphuret of tin is a compound of 55 tin + 15 sulphur. Now 55 : 15 : : 14.705 : 4.015 = 2 atoms of sulphur very nearly.

Oberkampt has shown, that the sulphuret of gold is composed of 100 gold + 24.39 sulphur. Now 100 : 24.39 : : 24.838 : 6.057 = 3 atoms of sulphur very nearly.

According to the experiments of Sefstrom, black sulphuret of mercury is composed of 100 metal + 8.005 sulphur; and red sulphuret of 100 metal + 16.01 sulphur. Now 100 : 8.005 : : 25 : 2.001 and 100 : 16001 : : 25 : 4.002. But 2.001 and 4.002 are obviously equal respectively to 1 atom and 2 atoms of sulphur.

Galena is a compound of 100 lead + 15.42 sulphur. Now 100 : 15.42 : : 25.974 : 4.005 = 2 atoms of sulphur. Sir John Sinclair found a variety of galena in Caithness, which burned with a blue flame when held to a candle. It was analyzed by Dr Thomson, and found to contain double the quantity of sulphur in common galena. Hence it was a compound of 1 atom lead and 4 atoms sulphur. This variety must be scarce, for it has never been noticed by mineralogists.

Such are the sulphurets with the composition of which we are at present acquainted. A good number are of necessity omitted, because they have never been analyzed by chemists. It would be easy to state the composition of most of these from theory. But we do not see any advantage that would result to the science from such theoretical statements, unsupported by experiment.

Neither the *phosphurets* nor *carburets* have been examined with such precision as to enable us to exhibit their composition in a table. It is probable that the phosphurets are analogous to sulphurets. But certainly no such analogy holds with the carburets and *silicarets;* both of which exist, though they have been hitherto too slightly examined to give us any exact notions of their constitution. Carbon seems to combine with a great number of atoms of iron, in cast iron, and with a still greater number in steel.

### 5. *Organic Bodies.*

Hitherto the only correct analysis of organic bodies are those made by Berzelius, and published in the fifth volume of the *Annals of Philosophy.* As these experiments are so recent as not to be generally known, we shall state in the table the results of each analysis, and likewise the number of atoms of which the body is composed.

| | Constituents. | | Atoms. | Weight. |
|---|---|---|---|---|
| 156 Citric acid | oxygen | 55.096 | 2 | = 3.634 |
| | carbon | 41.270 | 2 | |
| | hydrogen | 3.634 | 1 | |
| | | 100.000 | 5 | |
| 157 Tartaric acid | oxygen | 60.213 | 10 | = 16.668 |
| | carbon | 35.980 | 8 | |
| | hydrogen | 3.807 | 5 | |
| | | 100.000 | 23 | |
| 158 Oxalic acid | oxygen | 66.534 | 12 | = 18.140 |
| | carbon | 33.222 | 8 | |
| | hydrogen | 0.244 | 1 | |
| | | 100.000 | 21 | |
| 159 Succinic acid | oxygen | 47.888 | 3 | = 6.268 |
| | carbon | 47.600 | 4 | |
| | hydrogen | 4.512 | 2 | |
| | | 100.000 | 9 | |
| 160 Acetic acid | oxygen | 46.82 | 3 | = 6.400 |
| | carbon | 46.83 | 4 | |
| | hydrogen | 6.35 | 3 | |
| | | 100.00 | 10 | |
| 161 Gallic acid | oxygen | 38.02 | 3 | = 7.517 |
| | carbon | 56.96 | 6 | |
| | hydrogen | 5.02 | 3 | |
| | | 100.00 | 12 | |
| 162 Saclactic acid | oxygen | 61.465 | 8 | = 12.415 |
| | carbon | 33.430 | 6 | |
| | hydrogen | 5.105 | 5 | |
| | | 100.000 | 19 | |
| 163 Benzoic acid | oxygen | 20.43 | 3 | = 14.306 |
| | carbon | 74.41 | 15 | |
| | hydrogen | 5.16 | 6 | |
| | | 100.00 | 24 | |
| 164 Tannin from Nutgalls | oxygen | 44.654 | 4 | = 8.902 |
| | carbon | 51.160 | 6 | |
| | hydrogen | 4.186 | 3 | |
| | | 100.000 | 13 | |
| 165 Common sugar | oxygen | 49.015 | 20 | = 40.796 |
| | carbon | 44.200 | 24 | |
| | hydrogen | 6.785 | 21 | |
| | | 100.000 | 65 | |
| 166 Sugar of milk | oxygen | 53.359 | 8 | = 16.566 |
| | carbon | 39.474 | 10 | |
| | hydrogen | 7.167 | 8 | |
| | | 100.000 | 26 | |
| 167 Gum Arabic | oxygen | 51.306 | 12 | = 23.347 |
| | carbon | 41.906 | 13 | |
| | hydrogen | 6.788 | 12 | |
| | | 100.000 | 37 | |

Atomic Theory.

Atomic Theory.

| | Constituents. | | Atoms. | Weights. |
|---|---|---|---|---|
| 168 Potatoe starch | oxygen | 49.455 | 12 | =24.230 |
| | carbon | 43.481 | 14 | |
| | hydrogen | 7.064 | 13 | |
| | | 100.000 | 39 | |

For the way in which these experiments were made, we refer to the original paper of Berzelius, quoted above. We have no doubt that the results are very near approximations to the truth, though some slight corrections may perhaps be necessary. The great number of atoms that enter into the composition of some of these bodies is very remarkable. We would find it difficult to explain the nature of such combinations, without having recourse to some hypothesis respecting the nature of elasticity. Twelve atoms of oxygen, and 13 of hydrogen, in a compound possessed of so little elasticity as potatoe starch, is very extraordinary. The old opinion of Dr Black and his contemporaries was, that bodies owe their elasticity to a quantity of heat combined with them. Of course, when the heat is separated, the elasticity disappears. Were we to suppose, in conformity with this hypothesis, that the oxygen and hydrogen which exists in organized bodies, are deprived of the heat requisite to give them the elastic form, there would be no difficulty in understanding how so many atoms unite together, and have no tendency to separate, and how the compound is so speedily decomposed by the application of heat, or by combustion.

Thus, we have gone over all the primary compounds which have been subjected to examination by chemists, without finding a single exception to the atomic theory. On the contrary, the great and unexpected elucidation which this theory throws upon the nature of chemical combinations, is highly pleasing. The simplicity of the proportions in which the atoms of unorganic matter unite, is equally delightful and astonishing, and throws a degree of grandeur around the science, hitherto conversant in minute and apparently unconnected combinations, fully equal to what distinguishes the sublimest branch of mechanical philosophy. The operations of nature are everywhere equally grand, and regulated by general principles equally simple and luminous, whether we examine the laws which regulate the motions of the solar system, or the minutest compound to be found in the terrestrial globe. Let us now examine the secondary compounds, that we may be able to judge how far they come under the dominion of the Atomic Theory.

## IV. Composition of Secondary Compounds.

Here, our task is much more difficult, and the field in a great measure unexplored, or only partially so. The secondary compounds are very numerous, amounting to several thousands. Accurate chemical analysis cannot be dated farther back than a few years. A correct knowledge of the whole of these compounds, therefore, is not to be expected. But, from the indefatigable zeal, uncommon accuracy, and gigantic industry of Berzelius, we have it in our power to examine the composition of many genera of salts with considerable precision; supposing always that the laws which he has pointed out respecting the combination of acids and bases be precise. We shall continue the method which we adopted when treating of the primary compounds; namely, exhibit tables of the composition of the different genera of secondary compounds, and then give the documents on which these tables were founded.

### 1. *Hydrates.*

| | Number of Atoms. | Weight of an Integrant Particle. |
|---|---|---|
| 169 Hydrate of potash | 1 *p* + 1 *w* | 7.125 |
| 170 Hydrate of soda | 1 *s* + 2 *w* | 10.125 |
| 171 Hydrate of lime | 1 *l* + 1 *w* | 4.750 |
| 172 Hydrate of barytes | 1 *b* + 1 *w* | 10.875 |
| 173 Hydrate of strontian | 1 *st* + 1 *w* | 7.725 |
| 174 Hydrate of magnesia | 2 *m* + 1 *w* | 6.125 |
| 175 Hydrate of alumina | 1 *a* + 1 *w* | 3.250 |
| 176 Hydrate of glucina | 1 *g* + 1 *w* | 10.965 |
| 177 Hydrate of yttria | 1 *y* + 3 *w* | 11.750 |
| 178 Hydrate of zirconia | 1 *z* + 1 *w* | 6.750 |
| 179 Hydrate of silica | 1 *si* + 1 *w* | 3.125 |
| 180 Hydro-sulphuric acid, or acid of 1.85 | 1 *s* + 1 *w* | 6.125 |
| 181 2d hydrate of sulphuric acid, or acid of 1.780 | 1 *s* + 2 *w* | 7.250 |
| 182 3d hydrate of sulphuric acid, or acid of 1.65 | 1 *s* + 3 *w* | 8.375 |
| 183 Hydronitric acid, or acid of 1.62 | 2 *n* + 1 *w* | 14.625 |
| 184 2d hydrate of nitric acid, or acid of 1.54 | 1 *n* + 1 *w* | 7.875 |
| 185 3d hydrate of nitric acid, or acid of 1.42 | 1 *n* + 2 *w* | 9.000 |
| 186 4th hydrate of nitric acid, or acid of 1.350 | 1 *n* + 3 *w* | 10.125 |
| 187 Hydrophosphorous acid | 2 *p* + 1 *w* | 6.375 |
| 188 Hydrate of boracic acid | 1 *b* + 2 *w* | 4.997 |
| 189 Hydrate of peroxide of copper | 1 *c* + 1 *w* | 11.125 |
| 190 Hydrate of black oxide of iron | 1 *i* + 1 *w* | 10.240 |
| 191 Hydrate of red oxide of iron | 1 *i* + 1 *w* | 11.240 |
| 192 Hydrate of deutoxide of tin | 1 *t* + 1 *w* | 17.875 |
| 193 Hydrate of peroxide of tin | 1 *t* + 1 *w* | 19.875 |
| 194 Hydrate of deutoxide of nickel | 1 *n* + 3 *w* | 12.701 |
| 195 Hydrate of deutoxide of cobalt | 1 *c* + 1 *w* | 11.458 |
| 196 Hydrate of protoxide of manganese | 1 *m* + 1 *w* | 9.250 |
| 197 Hydrate of oxide of arsenic | 1 *o* + 1 *w* | 7.125 |
| 198 Hydrate of antimony | 2 *a* + 1 *w* | 31.625 |
| 199 Hydrate of oxalic acid | 1 *o* +12 *w* | 31.724 |
| 200 Hydrate of tartaric acid | 1 *t* + 2 *w* | 18.932 |
| 201 Hydrate of citric acid | 2 *c* + 3 *w* | 10.664 |

By hydrate of potash is understood caustic potash, that has been exposed to a red heat. For it is well known, that the whole water cannot be expelled from potash by heat. The statement in the table supposes this hydrate to be composed of 100 potash + 18.867 water. Now Davy, by heating potash and boracic acid together, actually separated between 17 and 18 water. Berzelius obtained 16 *per cent.*, which is very near the exact quantity. For if our determination be correct, 100 potash ought to contain 15.872 water.

Hydrate of soda has never been analyzed. The number in the table is given from this analogy. Berzelius has shown, that the hydrates of the salifiable bases, are in fact salts, the water acting the part of an acid, and saturating the base. Now, in all the salts of soda hitherto examined, 1 integrant particle of the soda is always combined with 2 integrant particles of acid. We suppose the same thing to hold with water.

Slacked lime, which is the hydrate, according to the experiments of Lavoisier, is composed of 100 lime + 28.7 water; according to Dalton, of 100 lime + 33.333 water. The mean of these two results gives the statement in the table almost precisely.

The experiments of Berthollet and Berzelius prove, that hydrate of barytes is a compound of 100 barytes + 12.121 water. The statement in the table supposes it a compound of 100 barytes + 11.632, which coincides very nearly.

Hydrate of strontian is given merely from analogy. Crystallized strontian is a compound of 1 particle strontian + 13 particles of water.

According to Davy, hydrate of magnesia contains one-fifth of its weight of water. Hence the statement in the table. Probably there may be another hydrate composed of 1 integrant particle magnesia, and 1 integrant particle water, but which cannot be obtained in a separate state.

Wavellite, which is a native hydrate of alumina, is composed of 74 alumina + 26 water. Hence the composition of the hydrate in the table.

Hydrate of glucina has never been analyzed. According to Klaproth, hydrate of yttria is composed of 69 yttria + 31 water. According to Davy, zirconia, when in the state of a hydrate, contains more than one-fifth of its weight of water.

Hydrate of silica has never been analyzed. But silica absorbs about one-fourth of its weight of water.

The hydrate of sulphuric and nitric acids were determined by Mr Dalton. Sulphuric acid of 1.85 is the strongest that can be made. It is composed of 100 real acid + 22.64 water. The second hydrate is composed of 100 acid + 45.28 water. It freezes at the temperature of 42°. It was upon it that Mr Keir made his experiments.

The hydrate of phosphorous acid was determined by Sir Humphry Davy. See his *Elements of Chemical Philosophy*, p. 289.

Davy found hydrate of boracic acid composed of 57 acid + 43 water. Now, this agrees very nearly with the statement in the table.

Hydrate of peroxide of copper is obtained by precipitating the sulphate or nitrate of copper, by means of an alkali. It is a blue powder composed, according to Davy, of 9 peroxide of copper + 1 water. This agrees nearly with the statement in the table.

According to Berzelius, when iron is kept in water, a hydrate is formed, composed of 128 parts of black oxide of iron + 15.866 water. Now, this coincides almost exactly with 1 integrant particle of black oxide, 1 integrant particle of water.

Hydrate of the red oxide of iron is the orange powder obtained from persulphate of iron by an alkali. It has never been analyzed.

The hydrate of deutoxide of tin, is the white powder obtained by precipitating the recent solution of tin in muriatic acid. According to Proust, it is composed of 95 oxide + 5 water. This approaches most nearly to the statement in the table. The other hydrate of tin has never been analyzed.

The hydrate of nickel is a green powder obtained by precipitating sulphate of nickel by an alkali. According to Davy, more than one-fourth of its weight is water. This statement approaches most nearly to the supposition, that it contains 3 particles of water + 1 oxide of nickel.

The hydrates of cobalt, manganese, and arsenic, have never been analyzed. They are stated merely from analogy.

According to Berzelius, the tritoxide of antimony forms a hydrate composed of 95.22 oxide + 4.78 water. This approaches most nearly to the statement in the table; but does not agree with it.

The hydrates of oxalic acid, tartaric acid, and citric acid, were determined by Berzelius. Crystallized oxalic acid is composed of 58 acid + 42 water; crystallized tartaric acid of 88.75 acid, and + 11.25 water; and crystallized citric acid of 100 acid + 20.5 water. These proportions coincide with the statements in the table very nearly.

Thus, it appears that the composition of the hydrates, as far as they have been examined, agree perfectly with the atomic theory. We see, likewise, that the number of particles of water which enter into combination with other bodies is not confined within such narrow limits as most of the other primary compounds are. In many hydrates, only a single particle of water is found; while, in others, no fewer than 12 particles exist.

Let us now proceed to examine the salts, in order to judge how far their composition is regulated by the laws of the atomic theory.

2. *Salts.*

The salts are very numerous, and have been divided into as many genera as there are acids entering into their composition. Some of these genera have been carefully analyzed, while others still remain in a great measure unknown.

GENUS I.—*Sulphates.*

| | | Number of Atoms. | | Weight of an Integrant Particle. |
|---|---|---|---|---|
| 202 | Sulphate of potash | $1s + 1p$ | . | 11.000 |
| 203 | Bisulphate of potash | $2s + 1p$ | . | 16.000 |

| | | Number of Atoms. | Weight of an Integrant Particle. |
|---|---|---|---|
| 204 | Sulphate of soda | 2 s + 1 s | 17.875 |
| 205 | Sulphate of ammonia | 1 s + 1 a | 7.125 |
| 206 | Sulphate of magnesia | 1 s + 1 m | 7.500 |
| 207 | Sulphate of lime | 1 s + 1 l | 8.625 |
| 208 | Sulphate of barytes | 1 s + 1 b | 14.750 |
| 209 | Sulphate of strontian | 1 s + 1 str | 11.500 |
| 210 | Sulphate of alumina | 1 s + 1 a | 7.125 |
| 211 | Subsulphate of alumina | 1 s + 2 a | 9.250 |
| 212 | Sulphate of yttria | 1 s + 1 y | 13.400 |
| 213 | Sulphate of glucina | 1 s + 1 g | 14.833 |
| 214 | Sulphate of zirconia | 1 s + 1 z | 10.625 |
| 215 | Alum | 6 s + 1 p + 5 a | 46.625 |
| 216 | Sulphate of potash and ammonia | 2 s + 1 p + 1 a | 18.125 |
| 217 | Sulphate of potash and magnesia | 3 s + 1 p + 2 m | 26.000 |
| 218 | Sulphate of soda and ammonia | 7 s + 1 so + 6 a | 55.625 |
| 219 | Sulphate of soda and magnesia | 4 s + 1 so + 3 m | 35.375 |
| 220 | Sulphate of magnesia and ammonia | 3 s + 2 m + 1 a | 22.125 |
| 221 | Sulphate of copper | 2 s + 1 c | 20.000 |
| 222 | Subsulphate of copper | 1 s + 2 c | 25.000 |
| 223 | Sulphate of iron | 2 s + 1 i | 19.115 |
| 224 | Subsulphate of iron | 2 s + 3 i | 37.345 |
| 225 | Persupersulphate of iron | 3 s + 1 i | 25.115 |
| 226 | Sulphate of lead | 2 s + 1 l | 38.000 |
| 227 | Sulphate of zinc | 1 s + 1 z | 9.095 |
| 228 | Sulphate of mercury | 1 s + 1 m | 31.000 |
| 229 | Persulphate of mercury | 1 s + 1 m | 32.000 |
| 230 | Sulphate of silver | 1 s + 1 si | 19.750 |
| 231 | Sulphate of bismuth | 1 s + 1 b | 15.000 |
| 232 | Sulphate of nickel | 1 s + 1 n | 14.305 |
| 233 | Sulphate of cobalt | 2 s + 1 c | 19.326 |
| 234 | Sulphate of manganese | 2 s + 1 m | 17.833 |
| 235 | Sulphate of uranium | 1 s + 1 u | 20.000 |
| 236 | Persulphate of platinum | 2 s + 1 p | 24.125 |

Dr Thomson found sulphate of potash composed of 42.2 acid + 50.1 potash, which corresponds with the tabular statement almost exactly. Dr Wollaston has shown, that the bisulphate contains just double the acid in the sulphate.

Sulphate of soda, according to Wenzel, is composed of 100 acid + 78.32 base; according to Berzelius, of 100 acid + 79.34. The tabular statement supposes a combination of 100 acid + 78.82 soda. Now, this is the mean of the two experiments.

According to Berzelius, sulphate of ammonia is composed of 100 acid + 42.561 ammonia. Now 100 : 42.561 : : 5 : 2.128 = weight of an integrant particle of ammonia very nearly.

According to Berzelius, sulphate of magnesia is composed of 100 acid + 50.06 magnesia. Now 100 : 50.06 : : 5 : 2.503 = weight of an integrant particle of magnesia very nearly.

Sulphate of lime, according to the analysis of Berzelius, is composed of 100 acid + 72.41 base. Now, 100 : 72.41 : : 5 : 3.620 = weight of an integrant particle of lime almost exactly.

Sulphate of barytes, according to the analysis of Berzelius, is composed of 100 acid + 194 barytes. Now 100 : 104 : : 5 : 9.700 = weight of an atom of barytes very nearly.

The weight of an integrant particle of strontian was deduced from an accurate analysis of carbonate of strontian, which was found to consist of 29.9 carbonic acid + 70.1 strontian.

According to Berzelius's analysis, sulphate of alumina is composed of 100 acid + 42.722 alumina. It was from this analysis, that the weight of an integrant particle of alumina was determined. Of course, the statement in the table must coincide with it entirely.

The sulphates of yttria, glucina, and zirconia, have not hitherto been analyzed. Their composition is stated merely from analogy.

Alum, according to the experiments of Berzelius, is composed of

| | |
|---|---|
| Sulphuric acid | 34.33 |
| Alumina | 10.86 |
| Potash | 9.81 |
| Water | 45.00 |
| | 100.00 |

Now, this will be found to consist of an integrant particle of sulphate of potash, combined with five integrant particles of sulphate of alumina.

Sulphate of potash and ammonia is a compound of 1 integrant particle of sulphate of potash, and 1 integrant particle of sulphate of ammonia. All the other triple salts are formed in the same way, by the combination of 1 integrant particle of 1 salt, with 1 or more integrant particles of another salt. Sulphate of potash and magnesia consists of 1 integrant particle of sulphate of potash, united with 2 integrant particles of sulphate of magnesia; sulphate of soda and ammonia is composed of 1 integrant particle of sulphate of soda, united with 6 integrant particles of sulphate of ammonia; sulphate of soda and magnesia of 1 integrant particle of sulphate of soda, and 3 integrant particles of sulphate of magnesia; and sulphate of magnesia and ammonia of 2 integrant particles of sulphate of magnesia, and 1 integrant particle of sulphate of ammonia.

As an atom of sulphuric acid weighs 5, and an atom of black oxide of copper 10, it is obvious that if sulphate of copper contains 2 particles of acid, and 1 of oxide, the weight of the two constituents must be equal. Now, according to Proust, the salt is composed of 33 acid + 32 base; according to Berzelius of 49.1 acid + 50.9 oxide. The mean of these two experiments gives us the salt composed of 100 acid + 100.317 base, which almost coincides with theory. According to Proust, the subsulphate of copper is composed of 18 acid + 68 oxide. Now 5 : 10 × 2 : : 18 : 72, this does not differ much from the analysis, if we consider the difficulty in getting the salt quite pure, and in a proper state for examination.

Sulphate of iron, according to the analysis of Ber-

zelius, is composed of 100 acid + 88 black oxide of iron. Now $5 \times 2 : 9.115 :: 100 : 91.15$ = very nearly to 88. The composition of subsulphate of iron is founded on the analysis of Berzelius. According to him, it is composed of 100 acid + 266 oxide. Now, these proportions agree only with the supposition of 2 particles of acid, and 3 of oxide. Therefore, if this analysis be correct, the axiom of Berzelius, that in inorganic compounds, one of the constituents enters always in the state of a single atom, does not apply to the salts. Indeed, we shall find other similar cases suggested by Berzelius himself, in which the same thing is to be observed. Nor need we be surprised that combinations of 2 particles with 3 should sometimes occur. It is fortunate for chemists that they occur so rarely, as only to constitute exceptions to a general rule. The subsulphate of iron may be represented in this manner $2\ (sO^3) + 3\ (1O^2)$. The first of the terms represents the sulphuric acid, two particles composed each of 1 atom sulphur, and 3 atoms oxygen. The second term represents the oxide of iron, 3 particles composed each of 1 atom iron, and 2 atoms oxygen. We request the reader's attention to this compound; because it has been brought forward by Berzelius as an objection to the atomic theory. For our parts, we do not perceive any inconsistency whatever between such compounds and the atomic theory; though, no doubt, it is inconsistent with one of the empirical laws which Berzelius wishes to establish. But it is always too soon to lay down general laws, when a subject is under discussion.

According to Berzelius, the persupersulphate of iron is composed of 100 acid + 65.5 peroxide of iron. Now, this analysis agrees very nearly with 3 integrant particles of acid, united to 1 integrant particle of peroxide. The persulphate is probably a compound of 2 particles of acid, and 1 particle of peroxide. Mr Dalton has objected this salt as inconsistent with Berzelius's law, that the oxygen in the acid is always a multiple of the oxygen in the oxide by a whole number. But the law holds, in this case, as it does with all the rest of the sulphates. Its composition is not equally compatible with Gay-Lussac's law, that the quantity of acid in a salt is always proportional to the quantity of oxygen in the base. For the black and red oxides of iron, it would seem, combine with the same weight of acid, though the red contains one-third more oxygen than the black.

Sulphate of lead, according to the analysis of Berzelius, is composed of 100 acid + 280 yellow oxide of lead. Dr Thomson having repeated the experiment, obtained very nearly the same result. The difference amounted only to 1000 part. Now $100 : 280 :: 5 \times 2 : 28$ = an integrant particle of yellow oxide of lead very nearly.

The composition of sulphate of zinc, as given in the table, is founded on the analysis of that salt by Dr Thomson. It appears, from his experiments (*Annals of Philosophy*, II. 411.), that 100 sulphuric acid combine with 102.859 oxide of zinc. Now $100 : 102.859 :: 5 : 5.143$. Now 5.143 is very nearly the weight of a particle of oxide of zinc.

According to Berzelius, sulphate of mercury is composed of 16 acid + 84 oxide. Now $5 : 26 :: 16 : 83.2$, which almost coincides with the analysis. We have no good analysis of *torpeth mineral*, or persulphate of mercury; but it is probable that the two oxides of mercury, like those of iron, combine with the same quantity of sulphuric acid. On that supposition, it will be a compound of

| | |
|---|---|
| Sulphuric acid, - - - | 15.625 |
| Peroxide of mercury, - | 84.375 |
| | 100.000 |

Now, Berzelius gives us 12 acid + 88 oxide, which does not differ very much from our theoretic numbers, if we consider the difficulty of the analysis, and the chance of some of the acid adhering to the oxide.

According to Berzelius, sulphate of silver is composed of 25.78 acid + 74.22 oxide. Now $5 : 14.714 :: 25.78 : 75,865$, which corresponds with the analysis very nearly.

Lagerhjelm found sulphate of bismuth composed of 33.647 acid + 66.653 oxide. Now, this corresponds almost exactly with the statement in the table.

According to Tapputi, sulphate of nickel is composed of 100 acid + 87.266. Now, this does not differ very much from the statement in the table, which supposes the salt composed of 100 acid + 93.05 oxide.

According to the analysis of Rolhoff, sulphate of cobalt is composed of 52.11 acid + 47.89 oxide. If the statement in the table be correct, it will be composed of 51.744 acid + 48.256 oxide. Now, this may be considered as agreeing with the analysis, since the difference is within the limits of the unavoidable errors of experiment.

According to John, sulphate of manganese is composed of 100 acid + 91.326 protoxide. Dr Thomson lately analyzed this salt, and obtained for its constituents 100 acid + 71 protoxide. Now $100 : 71 :: 10 : 7.1$; and 7.1 does not differ much from the weight of a particle of protoxide of manganese. The mean of the two experiments gives 8.113, which comes still nearer the true result.

Sulphate of uranium has hitherto been analyzed by Bucholz only. He makes it a compound of 22.1 acid + 77.9 peroxide. If the statement in the table be correct, as is probable, it ought to be a compound of 25 acid + 75 peroxide.

The persulphate of platinum, according to Berzelius, is composed of 41.223 acid + 58.777 peroxide. Supposing the tabular statement correct, it ought to be a compound of 41.389 acid + 58.611 peroxide. Now, this is identical with the experimental result of Berzelius.

Thus we have gone over the sulphates, the genus of salts, which has been most accurately examined, and have found the whole of them to correspond most accurately with the atomic theory. They all agree with Berzelius's law, that the oxygen in the acid is a multiple by a whole number of the oxygen in the base, except in the instance of subsulphate of iron. But perhaps his law was only meant to ap-

ply to the neutral salts, and not to the subsalts or supersalts. His law, that the oxygen in the acid amounts to three times the oxygen in the base, holds in all the neutral sulphates, except the persulphate of mercury, and sulphate of uranium; and neither of these salts can be considered as analyzed with such accuracy as to lay much stress upon their composition, as stated in the table. Let us now examine the carbonates, which are likewise pretty accurately known.

Genus II.—*Carbonates.*

| | | Number of Atoms. | Weight of an Integrant Particle. |
|---|---|---|---|
| 237 | Bicarbonate of potash | 2 *c* + 1 *p* | 11.500 |
| 238 | Carbonate of potash - | 1 *c* + 1 *p* | 8.750 |
| 239 | Supercarbonate of soda | 3 *c* + 1 *s* | 16.125 |
| 240 | Carbonate of soda - | 2 *c* + 1 *s* | 13.375 |
| 241 | Bicarbonate of ammonia | 2 *c* + 1 *a* | 7.625 |
| 242 | Carbonate of ammonia | 1 *c* + 1 *a* | 4.875 |
| 243 | Carbonate of lime - | 1 *c* + 1 *l* | 6.375 |
| 244 | Carbonate of barytes | 1 *c* + 1 *b* | 12.500 |
| 245 | Carbonate of strontian | 1 *c* + 1 *str* | 9.250 |
| 246 | Bicarbonate of magnesia | 2 *c* + 1 *m* | 8.000 |
| 247 | Carbonate of magnesia | 1 *c* + 1 *m* | 5.250 |
| 248 | Carbonate of yttria - | 1 *c* + 1 *y* | 11.151 |
| 249 | Carbonate of zirconia | 1 *c* + 1 *z* | 8.375 |
| 250 | Carbonate of glucina - | 1 *c* + 1 *g* | 12.584 |
| 251 | Carbonate of silver - | 1 *c* + 1 *s* | 17.500 |
| 252 | Percarbonate of mercury | 1 *c* + 2 *m* | 56.750 |
| 253 | Percarbonate of copper | 1 *c* + 1 *cop* | 12.750 |
| 254 | Carbonate of iron - | 2 *c* + 1 *i* | 14.615 |
| 255 | Carbonate of nickel - | 2 *c* + 1 *n* | 14.805 |
| 256 | Carbonate of cobalt - | 2 *c* + 1 *cob* | 14.826 |
| 257 | Carbonate of lead - | 2 *c* + 1 *l* | 33.500 |
| 258 | Carbonate of zinc - | 1 *c* + 1 *z* | 7.845 |
| 259 | Carbonate of manganese | 2 *c* + 1 *m* | 13.335 |
| 260 | Carbonate of cerium - | 2 *c* + 1 *ce* | 19.349 |
| 261 | Percarbonate of cerium | 3 *c* + 1 *ce* | 23.100 |

The bicarbonate of potash is the common crystallized carbonate of the shops. If it be a compound of 2 integrant particles of carbonic acid, and 1 integrant particle of potash, it ought to consist of 47.835 acid + 52.165 base. Now, Berthollet obtained 47.64 acid + 52.36 base, a result which may be considered as quite identical with the theory, the difference being greatly within the limits of error from experiment. Dr Wollaston has shown, that the deliquescent carbonate contains just half the carbonic acid which exists in the bicarbonate.

The supercarbonate of soda is found native in Africa, and may be formed artificially, by passing a current of carbonic acid gas through common carbonate of soda dissolved in water. According to the analysis of Klaproth, it is composed of 39 acid + 38 base. Now, the tabular statement supposes it a compound of 39 acid + 37.247 base. We have different analyses of the carbonate of soda; but they do not agree well with each other. Bergman obtained 16 acid + 20 base; Darcet 16.04 acid + 20.85 base; and Klaproth 16 acid + 22 base. The last is the most correct. According to the tabular statement, which must be correct, the salt ought to be a compound of 16 acid + 22.921 base.

The analysis of the ammoniacal salts is attended with such difficulties, that great exactness can hardly be expected, except in those cases when the acid has a gaseous form. It is then easy to determine the volume of ammoniacal gas capable of saturating a given volume of the acid gas. Carbonic acid being a gas, the composition ammoniacal carbonates may be determined with accuracy. Now, 100 measures of carbonic acid condense and neutralize 100 measures of ammoniacal gas. This will be found, on making the calculation, to be 2 integrant particles of carbonic acid, and 1 integrant particle of ammonia, constituting the first of the ammoniacal salts in the table. Fifty measures of carbonic acid are likewise capable of combining with 100 measures of ammoniacal gas, constituting the second ammoniacal salt in the table. It has not been proved that any other carbonate of ammonia exists.

Supposing carbonate of lime a compound of 1 integrant particle of carbonic acid, and 1 integrant particle of lime, it should be a compound of 43.18 acid + 56.82 lime. Now, Dr Marcet obtained 43.9 acid + 56.1 base; and Dr Thomson, by a careful analysis of very pure calcareous spar, obtained 43.2 acid + 56.8 base. This last result is almost the very same with the theoretical result.

Carbonate of barytes, by the statement in the table, is a compound of 22.04 acid + 77.96 barytes. Now, Kirwan obtained 22 acid + 78 base; and Berzelius 21.6 acid + 78.4 base. Both of these results agree sufficiently with our theoretical result; the first, indeed, coincides with it.

The analyses of carbonate of strontian hitherto made cannot be expected to agree completely with our theoretical statement, because they have been all made upon the native carbonate of that earth, which always contains a certain proportion of carbonate of lime. According to an accurate analysis by the writer of this article, it is composed of 29.9 acid + 70.1 base. Klaproth's analysis gives us 30 acid + 69.5 base. The excess of acid is obviously owing to the presence of carbonate of lime in the native salt.

We have never seen any specimen of carbonate of magnesia composed of 1 integrant particle of acid, and one integrant particle of base, in commerce. But it occurs native in abundance, constituting an ingredient in the magnesian limestone, which is so abundant in the counties of Durham, York, and Derby, and which seems to constitute a peculiar formation. The bicarbonate may be formed by passing a current of carbonic acid through water in which magnesia is suspended. The salt is soluble in water, and crystallizes. It is composed of 69.911 acid + 30.089 base. Kirwan and Fourcroy found 66.6 acid + 33.3 base. Probably their salt was mixed with a little carbonate.

Carbonate of yttria was analyzed by Klaproth; and the tabular statement exactly coincides with

his result. We have no analysis of carbonates of zirconia, and glucina.

Berzelius found carbonate of silver a compound of 15.9 acid + 84.1 base. According to the statement in the table, it ought to be composed of 15.9 acid + 81.407 base, numbers which do not deviate far from those given by Berzelius.

We have no good analysis of the percarbonate of mercury. The statement in the table is given on the authority of Bergman; but is not very likely to be correct.

Percarbonate of copper, according to the analysis of Berzelius, is composed of 19.73 acid + 71.7 peroxide. Dr Thomson analyzed it, with precisely the same result. This analysis coincides exactly with the statement in the table.

Klaproth analyzed the carbonate of iron, and found it a compound of 38.3 acid + 61.6 base. This analysis corresponds sufficiently with the statement in the table.

Nickel and cobalt have so striking an analogy with iron in most particulars, that there is every reason for believing that the salts of the three metals are similarly constituted. Hence, as the carbonate of iron consists of 2 integrant particles of carbonic acid, and 1 integrant particle of black oxide of iron, we have supposed, in the table, that this is the case likewise with the carbonates of nickel and cobalt. The carbonate of nickel has been analyzed by Proust, and his result does not differ much from the tabular statement; but we have no analysis of the carbonate of cobalt.

Berzelius analyzed carbonate of lead, and found it a compound of 16.444 acid + 83.333. The analysis of other chemists corresponds nearly with this result. Now, our statement in the table supposes the salt a compound of 16.446 acid + 83.554 base, which may be considered as absolutely the same with the numbers given by Berzelius.

According to Mr Smithson, the carbonate of zinc is composed of 1 acid + 2 oxide. Now, the statement in the table supposes it a compound of 1 acid + 1.852 base; a coincidence as near as can be expected, when we consider the small quantity of salt upon which Mr Smithson makes his experiments.

If the carbonate of manganese be composed as stated in the table, it will be a compound of 34.16 acid + 50.476 base. John's analysis gives us 34.16 acid + 55.84 base; a result which does not correspond well. Hence there is reason to suspect inaccuracy.

The carbonates of cerium have been analyzed by Hisinger, and the results which he obtained agree tolerably well with the tabular statement.

Thus the carbonates correspond likewise with the Atomic Theory. They all agree with Berzelius's law, that the oxygen in the acid is a multiple by a whole number of the oxygen in the base. Most of them agree with his law, that the oxygen in the acid is double that in the base. But the carbonate of copper constitutes an exception to this rule. Indeed, we must expect to find some exceptions to these laws of Berzelius in almost every genus of salts. But it is surprising in how many unexpected

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cases they hold. Let us now examine the nitrates.



GENUS III.—*Nitrates.*

| | | Number of Atoms. | Weight of an Integrant Particle. |
|---|---|---|---|
| 262 | Nitrate of potash | 1 *n* + 1 *p* | 12.750 |
| 263 | Nitrate of soda | 2 *n* + 1 *s* | 21.375 |
| 264 | Nitrate of ammonia | 1 *n* + 1 *a* | 8.875 |
| 265 | Nitrate of magnesia | 1 *n* + 1 *m* | 9.250 |
| 266 | Nitrate of lime | 1 *n* + 1 *l* | 10.375 |
| 267 | Nitrate of barytes | 1 *n* + 1 *b* | 16.500 |
| 268 | Nitrate of strontian | 1 *n* + 1 *str* | 13.250 |
| 269 | Nitrate of ammonia and magnesia | 4 *n* + 3 *m* + 1 *a* | 36.625 |
| 270 | Nitrate of copper | 2 *n* + 1 *c* | 23.500 |
| 271 | Subnitrate of copper | 1 *n* + 2 *c* | 26.750 |
| 272 | Nitrate of iron | 2 *n* + 1 *i* | 22.625 |
| 273 | Pernitrate of iron | 3 *n* + 1 *i* | 29.375 |
| 274 | Nitrate of zinc | 1 *n* + 1 *z* | 10.840 |
| 275 | Nitrate of lead | 2 *n* + 1 *l* | 41.500 |
| 276 | 1st subnitrate of lead | 1 *n* + 1 *l* | 34.750 |
| 277 | 2d subnitrate of lead | 2 *n* + 3 *l* | 97.500 |
| 278 | 3d subnitrate of lead | 1 *n* + 3 *l* | 90.750 |
| 279 | Nitrate of nickel | 3 *n* + 1 *nick* | 29.555 |
| 280 | Subnitrate of nickel | 1 *n* + 7 *nick* | 71.885 |
| 281 | Nitrate of silver | 1 *n* + 1 *s* | 21.500 |
| 282 | Nitrate of mercury | 1 *n* + 1 *m* | 32.750 |
| 283 | Pernitrate of mercury | 1 *n* + 2 *m* | 60.750 |
| 284 | Subnitrate of platinum | 1 *n* + 4 *pl* | 53.250 |
| 285 | Nitrate of bismuth | 1 *n* + 1 *b* | 16.750 |
| 286 | Nitrate of uranium | 1 *n* + 1 *u* | 21.750 |

The analysis of the nitrates is attended with considerable difficulty, because we have no substance which forms an insoluble compound with nitric acid. We cannot, therefore, separate the acid by precipitation, as we do in the case of the sulphates, neither does it fly off when another acid is applied, as happens in the carbonates, so as to enable us to determine, by the loss of weight, how much acid the salt contains. Nevertheless, as a considerable number of the nitrates are destitute of water of crystallization, and composed only of the acid and base united together, we have the means of ascertaining the composition of such salts very accurately, by determining the proportion of base which they contain.

According to the analysis of Dr Thomson, nitre is composed of 100 acid + 83.823 base. According to Dr Wollaston, it is composed of 100 acid + 86.764 base. The statement in the table supposes it a compound of 100 acid + 88.8 potash. The difference between this result and experiment may be owing to our having made an atom of nitric acid a very little too great.

According to Dr Thomson, nitrate of soda is composed of 100 acid + 57.8 soda. According to Wenzel, it is composed of 100 acid + 60 base. Our tabular statement supposes 100 acid + 57.92, which almost coincides with the result of Dr Thomson.

Berzelius found nitrate of ammonia composed of 100 acid + 31.266 ammonia. Our tabular state-

ment supposes the salt to be composed of 100 acid + 30.853 ammonia, which very nearly coincides with the experiment of Berzelius.

According to Wenzel, nitrate of magnesia is composed of 100 acid + 38.88 base. According to Dr Thomson, of 100 acid + 34.729 base. Our tabular statement supposes it a compound of 100 acid + 37.881 base, which comes very near the experiment of Wenzel.

According to Kirwan, nitrate of lime is composed of 100 acid + 55.70 lime. According to Dr Thomson, of 100 acid + 53.091 lime. The tabular statement supposes it composed of 100 acid + 53.2 lime; a number which comes sufficiently near experiment.

According to Berzelius, nitrate of barytes is composed of 100 acid + 140.73 barytes. The tabular statement supposes 100 acid + 143.02 base, which does not differ more than 1 *per cent.* from experiment.

Vauquelin informs us that nitrate of strontian is composed of 100 acid + 98.341 base. Now, our statement supposes it a compound of 100 acid + 101.42 base, which is within less than 1 *per cent.* of the experimental result.

We suppose nitrate of ammonia and magnesia to be a compound of 3 integrant particles of nitrate of magnesia, and 1 integrant particle of nitrate of ammonia; because that comes nearest the analysis of Fourcroy. But indeed his analyses are very seldom to be depended on.

The nitrate of copper has not been analyzed. Its composition is inferred from the sulphate of copper, which has been examined with accuracy. Berzelius found the subnitrate composed of 100 acid + 349.2 base. Proust obtained from the same salt 100 acid + 418.7 base. The mean of these two experiments gives 100 acid + 383.95 base. Now, the constitution of the salt which we have supposed in the table requires its composition to be 100 acid + 386.67 base, which comes within half a *per cent.* of the preceding mean, and cannot, therefore, be far from the truth.

The nitrates of iron are given from theory and from analogy, as it would be scarcely possible, in the present state of the science of chemistry, to analyze them with accuracy.

Neither has the nitrate of zinc been analyzed; yet we do not think there can be any hesitation in admitting the statement given in the table to be correct.

According to Berzelius, octahedral nitrate of lead is composed of 100 acid + 205.1 oxide. This analysis, which we consider as exact, corresponds well with our statement in the table. The three subnitrates are described and analyzed by Berzelius (*Annals of Philosophy*, II. 278). The first contains 2 *ce* as much oxide as the octahedral nitrate, the second thrice as much, and the third six times as much. The second of these salts exhibits one of Berzelius's exceptions to the Atomic Theory. Its symbol would be, $1\ (a\ o^5) + 1\frac{1}{2}\ (l\ o^2)$, or 1 integrant particle of nitric acid united with $1\frac{1}{2}$ integrant particles of oxide of lead. This appears an absurdity at first sight, because half an integrant particle can have no existence. But when stated, as we have done in the table, the absurdity vanishes: the symbol then becomes $2\ (a\ o\ 5) + 3\ (l\ o\ 2)$, or two integrant particles of nitric acid, united to three integrant particles of oxide of lead. There is nothing in such an union incompatible with the Atomic Theory; though it is inconsistent with one of Berzelius's general laws, that, in all unorganic compounds, one of the elements enters always in the state of a single atom. In this compound there is no single atom. It consists of 11 atoms of oxygen, + 3 atoms of lead, + 2 atoms of azote.

Nitrate of nickel, according to Proust, is composed of 100 acid + 45.45 base. If so, its composition must be as represented in the table. Proust found the subnitrate composed of 100 acid + 735.3 oxide. This leads to the constitution of the salt in the table; if any confidence can be put in the accuracy of the analysis.

The analysis of Berzelius makes nitrate of silver a compound of 100 acid + 216.45 base. Proust gives us 100 acid + 233.33 base. The statement in the table supposes 100 acid + 216.286, which almost coincides with the result obtained by Berzelius.

Nitrate of mercury has not been analyzed. But Messrs Braamchamp and Siguiera Oliva found the pernitrate composed of 100 acid + 733.33 base. This constitutes a very near approximation to the tabular statement, especially when we consider the difficulty of the analysis.

Chenevix found the subnitrate of platinum composed of 100 acid + 809.09. This comes within $1\frac{1}{2}$ *per cent.* of our statement in the table; a sufficiently near coincidence, if the difficulty of analysis be attended to.

According to Berzelius, nitrate of bismuth is composed of 100 acid + 142.69 base. Our statement supposes it composed of 100 acid + 145.42; a sufficiently near coincidence for our purpose.

Nitrate of uranium, according to Bucholz, is composed of 100 acid + 232 base. This approaches pretty nearly to the statement in the table, which supposes the salt to be composed of 100 acid + 220.4 base.

Thus, we have gone over the composition of the nitrates, without finding any thing inconsistent with the Atomic Theory. On the contrary, they agree with that theory so exactly, wherever accurate methods of analysis can be had recourse to, that we may apply the theory, without hesitation, to determine the composition of those nitrates which cannot, in the present state of the science, be analyzed correctly. But, when we apply Berzelius's law, that the oxygen in the acid is a multiple of the oxygen in the base, by a whole number to the nitrates, we find that it fails in several cases, though it holds in the greatest number. As nitric acid contains 5 atoms of oxygen, it is obvious that it cannot combine with a single particle of a deutoxide, without transgressing the rule. But Berzelius has fallen upon a way of reconciling the nitrates to his law. According to him, azote is a compound of 1 atom of oxygen, and 1 atom of *nitricum*, so that nitric acid, according to him, is a compound of 6 atoms oxygen, and 1 atom nitricum. This opinion is certainly plausible, though it cannot

be adopted till something better than mere theory is brought forward in support of it. Let us now examine the phosphates, a genus of salts still much more imperfectly analyzed than any of the three preceding genera.

Genus IV.—*Phosphates.*

| | Number of Atoms. | Weight of an Integrant Particle. |
|---|---|---|
| 287 Phosphate of potash | 1 *ph* + 1 *p* | 9.625 |
| 288 Biphosphate of potash | 2 *ph* + 1 *p* | 13.250 |
| 289 Subphosphate of potash | 1 *ph* + 2 *p* | 15.625 |
| 290 Phosphate of soda | 2 *ph* + 1 *s* | 15.125 |
| 291 Biphosphate of soda | 4 *ph* + 1 *s* | 22.375 |
| 292 Phosphate of ammonia | 5 *ph* + 4 *a* | 26.625 |
| 293 Biphosphate of ammonia | 5 *ph* + 2 *a* | 22.875 |
| 294 Quadrosteophosphate of lime | 5 *ph* + 1 *l* | 21.750 |
| 295 Binosteophosphate of lime | 5 *ph* + 2 *l* | 25.375 |
| 296 Bigephosphate of lime | 5 *ph* + 3 *l* | 29.000 |
| 297 Osteophosphate of lime * | 5 *ph* + 4 *l* | 32.625 |
| 298 Phosphate of lime | 5 *ph* + 5 *l* | 36.350 |
| 299 Gephosphate of lime † | 5 *ph* + 6 *l* | 39.975 |
| 300 Phosphate of barytes | 1 *ph* + 1 *b* | 13.375 |
| 301 Phosphate of strontian | 1 *ph* + 1 *str* | 10.125 |
| 302 Phosphate of magnesia | 1 *ph* + 2 *m* | 8.625 |
| 303 Protophosphate of copper | 1 *ph* + 1 *c* | 12.625 |
| 304 Perphosphate of copper | 1 *ph* + 2 *c* | 23.625 |
| 305 Protophosphate of iron | 2 *ph* + 1 *i* | 16.393 |
| 306 Perphosphate of iron | 2 *ph* + 1 *i* | 17.393 |
| 307 Phosphate of lead | 2 *ph* + 1 *l* | 35.250 |
| 308 Phosphate of zinc | 1 *ph* + 1 *z* | 8.720 |
| 309 Biphosphate of zinc | 2 *ph* + 1 *z* | 12.345 |
| 310 Phosphate of nickel | 2 *ph* + 1 *n* | 16.553 |

Phosphate of potash, supposing it composed of 1 integrant particle of acid, and 1 integrant particle of base, ought to consist of 100 acid + 166.762 potash. Now, according to the analysis of Saussure jun. it is composed of 100 acid + 185.714 base. According to Berthollet, it is composed of 100 acid + 199.242 base. The author of this article lately subjected all the three phosphates of potash to a careful analysis. The results agree exactly with the tabular number.

We are not acquainted with any analysis of phosphate of soda, except one made lately by Dr Thomson. He found it composed of 100 acid + 109.59 soda. Now, according to the statement in the table, it is composed of 100 acid + 109.533. In this salt, the difference between the theoretical and experimental result may be considered as nothing.

The phosphates of ammonia and of magnesia are given from analyses of these salts made by the author of this article, but not yet published.

Phosphate of magnesia and ammonia, according to the analysis of Fourcroy, is composed of equal parts of phosphate of magnesia and phosphate of ammonia. But this result not agreeing with the constituents of these salts, as determined by experiment, this triple salt has been left out of the table.

There can be no doubt that phosphate of lime is composed of an integrant particle of phosphoric acid, united with an integrant particle of lime. This is the case with the sulphate, carbonate, and nitrate of lime, and unless the phosphate of lime were so formed, Richter's law could not hold good. According to this constitution, the salt must consist of 100 acid + 100 base. We have a considerable number of analyses of phosphate of lime; but all deviating so much from each other, that little confidence can be put in any of them. According to Klaproth, it is composed of 100 acid + 254.281 lime. But the salt which he formed by saturating phosphoric acid with marble, certainly was not the common phosphate of lime, but a subsalt, which has not yet been accurately examined. According to Ekeberg (when his calculations are rectified), phosphate of lime is composed of 100 acid + 82.186 base. This approaches much nearer the true composition, though it is not correct. The salt which Ekeberg found exists, and constitutes earth of bones. It is the osteophosphate of the table. According to Fourcroy and Vauquelin, phosphate of lime is composed of 100 acid + 143.9 lime. Here there is still a greater error on the opposite side than that fallen into by Ekeberg. But their analysis approaches to that of apatite, the gephosphate of the table. The other phosphates of lime in the table were discovered by the author of this article, and are detailed by him in a paper on phosphoric acid, read to the Royal Society, but not yet published.

Phosphate of barytes, according to the experiments of Berzelius, is composed of 100 acid + 259.715 barytes. Our statement in the table, founded on evidence, which seems quite satisfactory, supposes it a compound of 100 acid + 270.477 base. The difference here between experiment and theory does not exceed 3 *per cent.*

If phosphate of strontian be composed of 1 integrant particle of phosphoric acid, and 1 integrant particle of strontian, as there can be no doubt is the case, then its composition must be 100 acid + 191.773 base. We have an analysis of this salt by Vauquelin, according to whom it is composed of 100 acid + 142.48 base. But the data upon which he founded his conclusions, were necessarily so inaccurate, in consequence of the erroneous notions which he entertained respecting the composition of phosphate of lime, that a nearer approach to accuracy could not, in his case, be expected. The numbers in the table are the result of experiments by the author of this article.

It seems to be a law in saline combinations, that a deutoxide always combines with two integrant particles of acid. Thus, black oxide of copper unites with two integrant particles of sulphuric acid, and likewise with two integrant particles of nitric acid.

* So called, because it is a constituent of bones.

† This is the apatite of mineralogists.

Hence we may conclude, that it will combine likewise with two integrant particles of phosphoric acid. According to this statement, it must be composed of 100 acid + 138.854 black oxide of copper. Now, according to the analysis of Chenevix, it is composed of 100 acid + 141.428 black oxide of copper. This agrees with the tabular statement very nearly.

We have the same reason for considering phosphate of iron as a compound of two integrant particles of acid, and one of deutoxide of iron. According to this statement, it ought to be composed of 100 acid + 126.667 black oxide of iron. We have no analysis of this sort. Lougier, indeed, has analyzed a substance which occurs in small prisms in Brazil, and in the Isle of France. He found it composed of 100 acid + 214.285 black oxide. This approaches to a compound of 1 integrant particle of acid, and 1 integrant particle of oxide. Dr Thomson found two phosphates composed as in the table.

The perphosphate of iron is a white insoluble powder, obtained by precipitating persulphate of iron by phosphate of ammonia. It has not been analyzed. Nor do we know whether the theoretical result, as stated in the table, can be admitted to much confidence. This salt is converted into a subsalt, by the action of an alkali.

Phosphate of lead has been analyzed with great care by three different chemists. According to Berzelius, it is composed of 100 acid + 380.565 base; according to Dr Wollaston, of 100 acid + 370.72 base; and according to Dr Thomson, of 100 acid + 398.49 base. The mean of these experiments gives us 100 acid + 38, nearly 3.258 base. This agrees with the composition of the salt, as stated in the table. It was from it, in part, that we deduced the weight and composition of phosphoric acid.

The phosphates of zinc, and phosphate of nickel, have been analyzed by Dr Thomson. The composition of these salts in the table is stated from this analysis.

There is no analysis of the phosphate of mercury. We do not even know if it exists. But the perphosphate of mercury has been analyzed by Messrs Braamcamp and Siguiera. According to them, it is composed of 100 acid + 250.887 peroxide of mercury. Now, if it be a compound of 3 integrant particles of acid and 1 integrant particle of base, its constituents ought to be 100 acid + 250.159 base. This may be considered as identical with the experiment, since the difference is far within the limits of unavoidable error, from the imperfection of our methods.

Thus it appears, not only that no exception to the atomic theory exists among the salts; but that it puts it in our power to determine the composition of all the genera of salts, provided we know the analysis of one species, with more accuracy than would result from ordinary experiment. We have not the least doubt, that, when an accurate analysis of the phosphates is published, it will be found in almost every instance to agree with our table. We shall give another example of a genus of salts, the constituents of which we have determined almost entirely from theory,—we mean the borates; for very few of them have been hitherto subjected to analysis.



GENUS V.—*Borates.*

| | | Number of Atoms. | Weight of an Integrant Particle. |
|---|---|---|---|
| 311 | Borate of potash | 1 *b* + 1 *p* | 8.733 |
| 312 | Sub-borate of potash | 1 *b* + 2 *p* | 14.733 |
| 313 | Borate of soda | 2 *b* + 1 *s* | 13.341 |
| 314 | Sub-borate of soda | 1 *b* + 2 *s* | 18.483 |
| 315 | Borate of ammonia | 1 *b* + 1 *a* | 4.858 |
| 316 | Sub-borate of ammonia | 1 *b* + 2 *a* | 6.983 |
| 317 | Borate of magnesia | 1 *b* + 1 *m* | 5.233 |
| 318 | Borate of lime | 1 *b* + 1 *l* | 6.358 |
| 319 | Borate of barytes | 1 *b* + 1 *bar* | 12.483 |
| 320 | Borate of strontian | 1 *b* + 1 *str* | 9.233 |
| 321 | Borate of alumina | 1 *b* + 1 *a* | 4.858 |
| 322 | Borate of yttria | 1 *b* + 1 *y* | 11.133 |
| 323 | Borate of glucina | 1 *b* + 1 *g* | 12.566 |
| 324 | Borate of zirconia | 1 *b* + 1 *z* | 8.358 |
| 325 | Borate of copper | 2 *b* + 1 *c* | 15.466 |
| 326 | Borate of iron | 2 *b* + 1 *i* | 14.581 |
| 327 | Borate of nickel | 2 *b* + 1 *n* | 14.771 |
| 328 | Borate of cobalt | 2 *b* + 1 *c* | 14.792 |
| 329 | Borate of lead | 2 *b* + 1 *l* | 33.466 |
| 330 | Borate of zinc | 1 *b* + 1 *z* | 7.828 |
| 331 | Borate of mercury | 1 *b* + 1 *m* | 28.733 |
| 332 | Borate of silver | 1 *b* + 1 *s* | 17.483 |
| 333 | Borate of bismuth | 1 *b* + 1 *b* | 12.733 |
| 334 | Borate of manganese | 2 *b* + 1 *m* | 10.566 |
| 335 | Borate of uranium | 1 *b* + 1 *u* | 15.733 |
| 336 | Borate of platinum | 1 *b* + 1 *p* | 15.894 |

We shall take one other genus of salts, as a farther elucidation of the atomic theory; and we shall select one of the vegetable acids, which have been analyzed by Berzelius, that we may be able to judge how far the weight of an integrant particle of the acid derived from his analysis, will agree with the constitution of the salts.

GENUS VI.—*Oxalates.*

| | | Number of Atoms. | Weight of an Integrant Particle. |
|---|---|---|---|
| 337 | Oxalate of potash | 1 *ox* + 1 *p* | 10.634 |
| 338 | Binoxalate of potash | 2 *ox* + 1 *p* | 15.268 |
| 339 | Quadroxalate of potash | 4 *ox* + 1 *p* | 24.536 |
| 340 | Oxalate of soda | 2 *ox* + 1 *s* | 17.150 |
| 341 | Oxalate of ammonia | 1 *ox* + 1 *a* | 6.783 |
| 342 | Oxalate of magnesia | 1 *ox* + 1 *m* | 7.211 |
| 343 | Oxalate of lime | 1 *ox* + 1 *l* | 8.254 |
| 344 | Binoxolate of lime | 2 *ox* + 1 *l* | 12.888 |
| 345 | Oxalate of barytes | 1 *ox* + 1 *b* | 14.365 |
| 346 | Oxalate of strontian | 1 *ox* + 1 *st* | 11.534 |
| 347 | Oxalate of alumina | 1 *ox* + 1 *a* | 6.770 |
| 348 | Oxalate of yttria | 1 *ox* + 1 *y* | 13.034 |
| 349 | Oxalate of glucina | 1 *ox* + 1 *gl* | 14.467 |
| 350 | Oxalate of zirconia | 1 *ox* + 1 *z* | 10.290 |
| 351 | Oxalate of copper | 2 *ox* + 1 *c* | 19.268 |

| | Number of Atoms. | Weight of an Integrant Particle. |
|---|---|---|
| 352 Oxalate of potash and copper | 2 ox + 1 p + 1 c | 29.902 |
| 353 Oxalate of soda and copper | 3 ox + 1 s + 1 c | 32.410 |
| 354 Oxalate of ammonia and copper | 2 ox + 1 a + 1 c | 26.051 |
| 355 Oxalate of iron | 2 ox + 1 i | 18.383 |
| 356 Peroxalate of iron | 3 ox + 1 i | 23.017 |
| 357 Oxalate of nickel | 2 ox + 1 n | 18.573 |
| 358 Oxalate of cobalt | 2 ox + 1 c | 18.594 |
| 359 Oxalate of lead | 2 ox + 1 l | 37.242 |
| 360 Oxalate of zinc | 1 ox + 1 z | 9.661 |
| 361 Oxalate of mercury | 1 ox + 1 m | 30.634 |
| 362 Oxalate of silver | 1 ox + 1 s | 19.348 |
| 363 Oxalate of bismuth | 1 ox + 1 b | 14.628 |
| 364 Oxalate of manganese | 2 ox + 1 m | 17.401 |
| 365 Oxalate of uranium | 1 ox + 1 u | 19.634 |
| 366 Oxalate of cerium | 2 ox + 1 c | 23.115 |
| 367 Oxalate of platinum | 1 ox + 1 p | 17.795 |

According to the analysis of Berzelius, exhibited in a preceding part of this article, oxalic acid is a compound of 21 atoms, namely, 12 atoms of oxygen, 8 atoms of carbon, and 1 atom of hydrogen. But there can be little hesitation in doubling the quantity of hydrogen found in this acid by Berzelius; because this will greatly increase the simplicity of the composition of the acid, and the difference is considerably within the unavoidable errors in such experiments. In that case, the acid would be constituted of 11 atoms; namely, 6 of oxygen, 4 of carbon, and 1 of hydrogen; and its weight would be 9.070. But the weight of an atom of oxalic acid, even when thus corrected, will not agree with the known constitution of the oxalates. Berzelius analyzed oxalate of lead with great care, and found it composed of 100 acid + 307.5 oxide of lead. Now, it appears from all the genera of salts which we have examined, that the yellow oxide of lead unites always with 2 integrant particles of acid. The weight of an integrant particle of yellow oxide of lead is 28.

Now, $307.5 : \frac{100}{2} :: 57 : 4.528 =$ the weight of an integrant particle of oxalic acid. Now, this is very nearly one half of the weight resulting from analysis. To obtain this weight, it would be necessary to quadruple the quantity of hydrogen found in oxalic acid by Berzelius, and to consider it as composed of 3 atoms oxygen, 2 atoms carbon, and 1 atom hydrogen. Now, it deserves to be noticed, that this is the constitution of oxalic acid adopted by Mr Dalton (*Annals of Philosophy*, III. 179.), obtained, we presume, from an examination of the composition of the oxalates, and from the analysis of oxalic acid, previously made by Dr Thomson and by Gay-Lussac and Thenard. Whatever confidence the analytical experiments of Berzelius may be entitled to, we have no alternative in the present case but to adopt the conclusion suggested by the oxalates. The analysis of these bodies is much easier, and therefore more likely to prove correct, than that of oxalic acid itself. We may adopt 4.625 as the weight of an atom of oxalic acid; and consider it as a compound of 6 atoms, 3 of oxygen, 2 of carbon, and 1 of hydrogen. Its composition would then be

| | |
|---|---|
| Oxygen - - - | 64.739 |
| Carbon - - - | 32.413 |
| Hydrogen - - - | 2.848 |
| | 100.000 |

We do not pretend to reconcile this result with that obtained by Berzelius; but the constitution of the oxalates obliges us to adopt it as nearest the truth.

We have three analyses of the oxalate of potash, one by Dr Thomson (*Phil. Trans.* 1807), one by Vogel (*Schweigger's Journal*, II. 470), and one by M. Berard (*Annals de Chimie*, 73. 270). The statement in the table supposes the salt a compound of 100 acid + 129.477 potash. Now, Dr Thomson's analysis gives us 100 acid + 122.86 base, Vogel's 100 acid + 132.558 base, and Berard's 100 acid + 102.757 base. The first two analyses, especially the second, are very near the truth. Berard's is a good deal more incorrect. Dr Wollaston has shown, that binoxalate of potash contains exactly twice as much acid, and quadroxalate of potash four times as much acid as neutral oxalate of potash.

If oxalate of soda be composed of two integrant particles of acid, and 1 of soda, it must be composed of 100 acid + 85.045 soda. Now, the analysis of Vogel gives us 100 acid + 82.563 base, which agrees very nearly with theory. The analysis of Thomson and Berard are both considerably more incorrect.

Supposing oxalate of ammonia to be constituted as represented in the table, it must be a compound of 100 acid + 46.374 ammonia. Now, the analysis of Berzelius gives us 100 acid + 45.264 base, and that of Berard 100 acid + 44.369 base. Both of these agree well with the tabular statement.

Superoxalates of soda and of ammonia exist, but we did not give them a place in the table, as they have been but superficially examined. The first is probably a compound of 3 integrant particles of acid, and 1 integrant particle of soda; the second no doubt contains 2 integrant particles of acid and 1 of ammonia. Oxalate of magnesia, supposing it constituted as in the table, is a compound of 100 acid + 55.610 magnesia. Now, Bergman's analysis gives us 100 acid + 53.846 base. This agrees sufficiently with the theory. The analysis of Thomson and Berard are both very faulty. It is not difficult to see how they were misled.

Oxalate of lime has been analyzed with great care by different chemists, Bergman, Thomson, Berard, Vogel, Gay-Lussac, and Thenard, &c. But the results differ considerably from each other. The reason is, that various oxalates of lime exist, and that experimenters are always sure to get a mixture of them, when they form oxalate of lime by precipitation. The neutral salt must be composed of 100 acid + 78.117 lime. Now, Vogel's analysis gives us 100 acid + 76 lime, which is sufficiently near to show us, that he calculated the composition of the neutral salt. Dr Thomson gives 100 acid + 60 lime,

this must have been a mixture of neutral oxalate and binoxalate of lime. Berard found 100 acid + 61.2 lime, and Thenard, and Gay-Lussac, nearly the same proportions. All these must have been mixtures.

The analyses of the oxalate of barytes hitherto made, do not correspond with its composition as represented in the table; owing, probably, to the same causes that have occasioned inaccuracy in the analysis of oxalate of lime. This salt ought to be composed of 100 acid + 209.991 barytes. Dr Thomson's analysis gives us 100 acid + 142.86 base, and Berard's 100 acid + 164.3 base. Both of these are very far from accurate.

Oxalate of strontian, according to the statement in the table, ought to be composed of 100 acid + 148.894 strontian. Now, according to Dr Thomson's analysis, it is composed of 100 acid + 151.51 base. This agrees sufficiently. Berard's analysis is much less accurate. He obtained 100 acid + 119.5 base. The oxalates of alumina, yttria, glucina, and zirconia, have not been analyzed. But there can be no hesitation in considering their composition as stated in the table to be correct.

Oxalate of copper, according to the constitution of it given in the table, is composed of 100 acid + 107.898 black oxide of copper. Now, Vogel found it composed of 100 oxide + 100 acid, including a little water. This agrees sufficiently with the theoretic statement. The three triple oxalates are composed respectively as follows:

1. One integrant particle oxalate of potash, + 1 integrant particle oxalate of copper.
2. 1 oxalate of soda + 1 oxalate of copper.
3. 1 oxalate of ammonia + 1 oxalate of copper.

This agrees with Vogel's analysis. He found oxalate of potash and copper composed of

| | |
|---|---|
| Acid - | 45 |
| Potash - | 30 |
| Oxide of copper | 25 |
| | 100 |

Oxalate of soda and copper of

| | |
|---|---|
| Acid - | 46.48 |
| Soda - | 19.02 |
| Oxide of copper | 23.50 |
| Water - - | 11.00 |
| | 100.00 |

And oxalate of ammonia and copper of

| | |
|---|---|
| Acid - | 47.5 |
| Ammonia - | 10.5 |
| Oxide of copper | 25.0 |
| Water - | 17.0 |
| | 100.0 |

The remaining oxalates, if we except the oxalate of lead, have not yet been subjected to an accurate analysis. The composition, as stated in the table, is deduced from a comparison with the other genera of salts, and there can be no doubt that, in general, it is correct.

It would be easy for us to exhibit the composition of the remaining genera of salts; but we have already extended this article to as great a length as is consistent with our limits. The remaining genera, indeed, have been so imperfectly examined, that they would throw no additional light on the atomic theory; though that theory would enable us to calculate their compositions in most cases with sufficient precision. We have omitted, likewise, the *chlorides* and *iodes*, two numerous classes of bodies analogous to the oxides to which the atomic theory applies, with as much precision as it does to those substances which we have examined in this article. But these two classes of bodies being but recently discovered, are not probably so familiar to the reader, as to warrant our introducing them without any previous explanation. (J.)

# ATTRACTION.

THE word ATTRACTION (see *Encyclopædia*), is used to denote what we observe, when one body approaches another, or tends to approach it, without any apparent impulse, or other cause, to which the motion can be ascribed.

General Observations.

We have instances of attraction when iron approaches the magnet,—when certain bodies are placed near an excited electric,—when a stone falls to the earth. We say likewise that the earth attracts the moon; by this mode of expression meaning no more than that the moon is continually deflected towards the earth, from the rectilineal course which it would otherwise pursue. It is likewise in this sense that we must be understood, when we say that the sun attracts all the planets.

In the instances already mentioned, attraction extends to a distance. In other cases, it is confined within limits so extremely narrow, as to become imperceptible at an interval which cannot be appreciated by the senses. Of this kind is the attraction which takes place between the particles of the same fluid, as is apparent from the round figure of small drops. To this class likewise belongs the attraction between fluid and solid bodies; whence originate the very interesting appearances observed in capillary tubes, and other kindred phenomena. An attraction between the small elementary particles of all solid bodies, is manifest from the force with which they cohere, or resist an endeavour to separate them. In many cases, the intensity of this force is prodigiously great in contact, or at the nearest distances; while it ceases to act, upon making the smallest separation between the parts. Lastly, Chemistry developes innumerable instances of attraction between the molecules of the bodies about which it is conversant; insomuch, that it is to this principle, under the name of affinity,

that we must ultimately ascribe the various decompositions and new combinations which occur in that science.

All these phenomena, although very different from one another in other respects, yet have this in common, that we observe, in certain bodies, a tendency to approach one another, and to resist a separation, with some degree of force. The facts are certain, and are attended with no ambiguity; and it is to express these facts that the term *attraction* is used in physics.

We likewise observe, in some bodies, a tendency to fly off from one another when they are brought near. This is called *repulsion*.

The word *force* has, in general, some degree of obscurity. It is used to denote the cause of motion; but we have no direct knowledge of it, and we judge of its intensity by the effect which we suppose it to produce. In all our reasoning concerning forces, it is the changes of motion which we measure and compare together, and which are really the subjects of our thoughts. Attraction and repulsion are forces, or principles of motion, known to us only by the phenomena we observe; but the circumstance of their implying action at a distance, is an additional source of obscurity, in which other kinds of force do not participate.

It certainly is inconceivable, that motion should be produced at a distance, when no connection can be traced between the body moved and that which is supposed to produce the motion. We are strongly impressed with the prejudice, that a body cannot act but where it is; and we find difficulty in admitting that the mere presence of two bodies, without the intervention of any mechanical means, can be a satisfactory cause of motion. On this account, Attraction has been classed by some with the occult qualities of the schools; and the favourers of this doctrine have been reproached with reviving exploded notions in philosophy. Impulse is a principle of motion more familiar to us, and to which we are not disposed to make equal objection. Whenever the communication of motion can be traced to this source, we are satisfied that the effect is justly explained. Hence, many philosophers have been of opinion, that impulse is the only cause of motion that can be admitted in physical science; and many attempts have been made to reduce to this principle, all cases in which distant bodies act on one another. With regard to these attempts, it will be sufficient to remark here, that they are all built upon hypothesis: no evidence is adduced to prove that such things exist, as the elastic ether, or gravific matter, which they set out with supposing. And, as far as such systems have no other object but to obviate the difficulty of action at a distance, this argument alone is sufficient to confute them, without adverting to the difficulties that attend each of them separately—their inconsistency with the received laws of motion—and the innumerable contradictions and improbabilities to which they are liable on every side.

A little reflection is sufficient to show, that, in reality, we have no clearer notion of impulse as the cause of motion, than we have of attraction. We can as little give a satisfactory reason why motion should pass out of one body into another, on their contact, as we can, why one body should begin to move, or have its motion increased, when it is placed near another body. It is equally impossible in both cases to prove that there is a necessary connection between the related facts; in this respect, both the phenomena are alike inexplicable.

When motion is produced by impulse, it is probably the circumstance of contact apparently taking place, which leads us to think that the effect is so clearly explained. It is in this manner only, or by actual contact, that we ourselves can move external objects. We have no power to produce motion in distant bodies, except by the intervention of other bodies on which we act immediately. Impulse is, therefore, a cause of motion familiar to us, and strikes us as the plainest, and most satisfactory, ultimate principle at which we can arrive. On the other hand, when one body attracts another at a distance, there is nothing familiar to us with which we can compare it; our curiosity is excited, and we are led to seek out some hidden connection between them.

But, it may be doubted whether there is actual contact in any case of the communication of motion. When a body is impelled by the air, it will hardly be affirmed that the particles of that elastic fluid are in contact with one another, since there is no space, however small, within which a given bulk of it may not be compressed, by applying an external force sufficiently great. The particles of air, therefore, act on one another at a distance; and the same thing must be true of all other elastic fluids. And, by the way, what is here said is sufficient to prove, that no scheme, founded on the hypothesis of an elastic ether, will enable us to account for attraction; because such a contrivance can do nothing more than substitute one species of action at a distance in the room of another. There is good reason to think that absolute contact never takes place in the component parts of the hardest and most compact solid bodies. This seems to be an unavoidable consequence of the fact, well established by experience, that all bodies contract in their bulk by cold, and expand by heat. It is, therefore, not only not impossible, but it is even in some degree probable, that the communication of motion may, in every instance, be a case of action at a distance.

If, then, we are apt to think that impulse is a clearer physical principle than attraction, there is, in reality, no good ground for the distinction; it has its origin in prejudice, and in our mistaking the proper object of natural philosophy. All our researches in nature are confined to the phenomena we observe, and to the laws by which they are regulated. A physical cause is no other than a general fact discovered by a careful observation, and an attentive comparison, of many particular and subordinate facts. We have no evidence, independent of experience, that any consequence, deduced from a physical cause, will actually take place. There is, in this case, no necessary connection from which we can, with absolute certainty, infer the expected event. If, then, we regard impulse and attraction as princi-

Attraction.

ples founded in fact, and regulated by laws, confirmed by observation and experiment, they are both equally entitled to be classed as physical causes, and they ought both to be admitted as of equal authority in explaining the phenomena of the universe.

If we turn our attention to the different kinds of attraction enumerated above, and inquire what progress has been made in the investigation of their laws of action, we shall find that, generally speaking, this branch of physics is little advanced. We are very imperfectly acquainted with magnetical and electrical attraction. We know still less of those attractive powers which take place at small distances, and which are confined within such narrow limits, that their mode of action escapes the observation of our senses. Attraction is, indeed, much used by philosophers to account for many important natural phenomena; but their explanations are often vague, and destitute of that precision which ought always to be aimed at in physical science. There is only one class of phenomena in which the laws of attraction have been fully developed. We allude to gravitation, that principle which occasions the fall of heavy bodies at the surface of the earth, and which retains the planets and comets in their orbits. Referring the other species of attraction, which are little susceptible of general discussion, to their several heads, we shall now confine our attention to gravitation.

Discovery of the Law of Gravitation.

Traces of the principle of gravitation are to be found in writers of great antiquity. But their speculations on this subject do not go beyond a vague notion of a tendency which the planets have to one another, or to a common centre. It would contribute little either to entertainment or instruction, to collect all the passages of ancient authors that speak of this principle. The revival of the true system of the world by Copernicus, introduced the most admirable simplicity in the explanation of the planetary motions, and likewise led to more just conjectures concerning the laws by which they are upheld. Copernicus himself attributed the round figure of the planets to a tendency which their parts possess of uniting with one another; thus extending to all the planets which we observe at the surface of the earth. He stopt short, indeed, at this point; conceiving attraction to be confined to the matter of each planet, without making it extend from one planet to another, so as to actuate all the bodies of the system. This step was made by the bold and systematic genius of Kepler. Adopting the opinion of Dr Gilbert of Colchester, that the earth is a great magnet, Kepler formed to himself a notion of attraction, in some respects remarkably just. He says that the earth and moon attract one another; and, were it not for some powers which retain them in their orbits, they would move towards one another, and would meet in their common centre of gravity. He attributes the tide to the moon's attraction (*virtus tractoria quæ in luna est*), which heaps up the waters of the ocean immediately under her. But in many respects, his notions of attraction were fanciful and extravagant; a more perfect knowledge of the laws of motion than had been attained to in his time, and a new geometry, were both wanting, in order to guide him in this research without danger of wandering. Yet he was able to penetrate so far into the causes of the planetary motions, as to foresee that they would not long continue latent; he tells us, he was persuaded that "the full discovery of those mysteries was reserved for the next age, when God would reveal them." So full an exposition of a physical system of the world, as is contained in the writings of Kepler, could not fail to draw the attention of succeeding philosophers. Many remarks concerning the principle of gravitation are to be found in the writings of Fermat, Roberval, Borelli, and other authors. But no one, before Newton, entertained so clear and systematic a view of the doctrine of universal gravitation as Dr Robert Hook. In his work on the motion of the earth, published in 1674, twelve years before the appearance of Newton's *Principia*, he lays down these three positions as the foundations of his system, viz.

"1*st*, That all the heavenly bodies have not only a gravitation of their parts to their own proper centre, but likewise that they mutually attract each other within their spheres of action.

"2*dly*, That all bodies having a simple motion, will continue to move in a straight line, unless continually deflected from it by some extraneous force, causing them to describe a circle, or an ellipse, or some other curve.

"3*dly*, This attraction is so much the greater, as the bodies are nearer."

The principle of universal gravitation is here very precisely enunciated. Dr Hook seems to have clearly perceived, that the planetary motions are the result of an attraction towards the sun, and of a rectilineal motion produced by a projectile force. Not having discovered the law according to which the force diminishes, as the distance from the sun increases, he contrived experiments to elucidate his theory. Having suspended a ball by means of a long thread, he placed another ball upon a table immediately under the point of suspension, and he caused the suspended ball to revolve round the stationary one. When the moveable ball was pushed laterally with a force properly adjusted to its deviation from the perpendicular, it described an exact circle round the ball on the table: in other cases, it described an ellipse, or an oval resembling an ellipse, having the other ball in the centre. Dr Hook observed, that although this experiment, in some measure, illustrated the planetary motions, yet it did not represent them accurately; because the ellipses which the planets describe, have the sun placed in one focus, and not in the centre. Thus, at the appearance of Newton, many things were known, or rather surmised, that prepared the way for the discovery of the principle which regulates the celestial motions. This does not detract, in any degree, from the glory of Newton, who, discarding the conjectures of his predecessors, proposed to himself to investigate, with mathematical strictness, the law of the attractive force, and to ascertain, with precision, its sufficiency to retain the planets in their orbits. He invented a new kind of geometry, which was necessary to enable him to accomplish his purpose. With this help, and by admitting no-

thing without the sanction of the established principles of Dynamics, he deduced from the motions of the celestial bodies, the law of universal gravitation, the most important and the most general truth hitherto discovered by the industry and sagacity of man, viz. "That all the particles of matter attract one another, directly as their masses, and inversely as the squares of their distances." The particular occasion which gave rise to the speculations of Newton, on the subject of gravity, is noticed in the life of that great man in the *Encyclopædia*; and, in the article Astronomy (Part IV. Chapter II.) there is an account of the several steps of the analytical process of reasoning, by which the above general law is inferred from the motions of the celestial bodies.

Having arrived at a principle which belongs to every part of matter, another inquiry comes into view. Setting out from this principle, it is now necessary to proceed in an inverted order, and deduce from it, by synthetical reasoning, the phenomena which we observe in the universe. The first step in this process, is to find out the attractive force of the planets, which arises from the united attractions of their component parts. Two things only are involved in this investigation, viz. the known law of attraction between the particles of matter, and the figure of the attracting bodies. This is a subject of great importance, and it is connected with some principal points of the system of the world, with the theory of the figure of the planets, that of the tides, and many other phenomena. It is but imperfectly discussed in Newton's immortal work; and there is no part of his philosophy which has been improved more slowly by the labours of his followers. We now propose to treat of it at some length, endeavouring to lay before our readers as complete a view of this part of science as the nature of our work will permit.

Definitions and Properties of Elliptical Spheroids.

We begin with laying down some definitions, and demonstrating some properties of elliptical spheroids.

*Def.* 1. A solid generated by the revolving of an ellipse about either axis is called a spheroid of revolution. If the ellipse revolve about the less axis, the spheroid is oblate; if about the greater axis, it is oblong.

Let $k$ and $k'$ denote the two axes of the spheroid, $k$ being that of revolution; and let $x$ and $y$ be two coordinates of a point in the surface of the spheroid, having their origin in the centre, $x$ being parallel to the axis of revolution, and $y$ perpendicular to it; then the equation of the spheroid, whether oblate or oblong, will be $\frac{x^2}{k^2} + \frac{y^2}{k'} = 1$.

*Def.* 2. An elliptical spheroid, in general, or an ellipsoid, is a solid bounded by a finite surface of the second order. Let ACB and ADE (Plate XXX. fig. 1. This figure represents one eighth of an ellipsoid contained in one of the solid angles formed by the three principal sections) be two ellipses that have the same axis AO, the same centre O, and their planes perpendicular to one another: from any point K in the common axis, let there be drawn ordinates in both ellipses, as KC and KD; then, having described an ellipse of which KC and KD are the semiaxes, the periphery DMC of that ellipse will be in the surface of the ellipsoid. This solid figure has a centre; three axes crossing one another at right angles in the centre; and three principal sections made by planes passing through every two of its axes.



Let $k$, $k'$, $k''$, denote the three semiaxes; viz. $k = \text{OB}$, $k' = \text{OE}$, $k'' = \text{OA}$: and let $x, y, z$ denote three rectangular coordinates of a point M in the surface, the coordinates being parallel to the axes, and having their origin in the centre; viz. $\text{MN} = x$, $\text{NK} = y$, and $\text{OK} = z$; then the equation of the surface will be $\frac{x^2}{k^2} + \frac{y^2}{k'^2} + \frac{z^2}{k''^2} = 1$; as it is easy to prove from the foregoing construction.

The ellipsoid becomes a sphere, when all the three axes are equal: it becomes a spheroid of revolution, when two of them are equal.

1. *If any plane cut an elliptical spheroid, the section will be an ellipse. In the spheroid of revolution, a section made by a plane perpendicular to the axis of revolution is a circle.*—All this follows so easily from the nature of the solids, that we need not stop to give a formal demonstration.

2. *If a straight line cut two concentric ellipses, that are similar and similarly situated, the parts of it between the outer and inner peripheries are equal to one another.*

Let AHBK and MDNC (Plate XXX. fig. 2.) be two similar and similarly situated ellipses that have the same centre O; and let the straight line AB cut them both; then AC and BD are equal. Bisect CD in L, and through L and the common centre draw the straight line HMNK to cut both ellipses. Because the ellipses are similar and similarly situated, and that CD is an ordinate of the diameter MN, it is plain that AB will be an ordinate of the diameter HK; wherefore, AB and CD being both bisected in L, AC is equal to BD.

3. *If there be two ellipses, one within the other, such that, any straight line being drawn to cut them, the parts of it between their peripheries are equal to one another; these ellipses are concentric, similar, and similarly situated.*

Let D (fig. 2.) be any point in the inner ellipse, and through D draw EF, terminating in the outer ellipse: then, if we make FG = DE, G must be a point in the inner ellipse. Hence all the points of the inner curve are determined, when the outer ellipse and the point D are given: wherefore there cannot be two different curves, both passing through D, that will answer the conditions. But an ellipse described through D, concentric with the outer ellipse, and similar to it, and similarly situated, will answer the conditions (2). Wherefore the two ellipses are concentric, and similar, and similarly situated.

4. *If a straight line be drawn to cut two elliptical spheroids, that have the same centre, and are similar and similarly situated, the part of it between the outer and inner surfaces will be equal to one another.*

Conceive a plane, which contains the straight line, to pass through the common centre of the solids;

the sections made by the plane will be concentric ellipses (1.); and these will be similar and similarly situated, because the solids are so: wherefore the parts of the straight line between the surfaces are equal (2.).

5. *If two elliptical spheroids that have the same centre, and are similar and similarly situated, be cut by a plane, the two sections will be concentric ellipses that are similar and similarly situated.*

For the sections are ellipses (1.); and, any straight line being drawn to cut them, the parts of it between the peripheries will be equal (4.): wherefore the ellipses are concentric, similar, and similarly situated (3.)

6. *Let ADE and CFG (fig. 3.) be two concentric ellipses that are similar and similarly situated; let AO and CO, in the same straight line, be two of their axes, and let DE, drawn through C, be perpendicular to AO; then if CF and CG be two chords of the interior ellipse that make equal angles with the axis CO, and if the chords DM and DN of the exterior ellipse be drawn respectively parallel to CF and CG; the sum of CF and CG will be equal to the sum or difference of DM and DN, according as they both fall on the same side, or on different sides of DE.*

For draw EP parallel to CF, and it will likewise be parallel to DM. Because CF and CG are equally inclined to CO and to DE, it is plain that DN and EP, which are parallel to CF and CG, are likewise equally inclined to DE: consequently $DN = EP$. Draw a straight line through the common centre to bisect DM in L, and that straight line will likewise bisect EP, parallel to DM, in H: and because the ellipses are similar and similarly situated, the same straight line will likewise bisect the chord CF of the interior ellipse, in K. Because $DC = CE$, therefore $DL + EH = 2CK = CF$. Wherefore $DM + DN = 2DL + 2EH = 2CF = CF + CG$.

The demonstration of the other case, when DM and DN fall on different sides of DE, is entirely similar.

*Some general Properties, resulting from the Law of Attraction, that obtains in Nature.*

7. *Let AB and EF (fig. 4.) be two indefinitely slender pyramids, that are similar to one another, and both composed of the same homogeneous matter, which attracts in the inverse proportion of the square of the distance: the attractions of the pyramids upon particles placed at the vertices A and E, are proportional to the length of the pyramids.*

Conceive each of the pyramids to be divided into an indefinitely great number of thin slices of equal thickness, by planes parallel to its base; then, if CD and GH be any two of these slices, their attractions upon particles placed at A and E, will be proportional to $\frac{CD}{AC^2}$, and $\frac{GH}{EG^2}$. Now, these are equal: for, the solids CD and GH, having the same thickness, they are proportional to the sections CM and GN, that is, to $AC^2$ and $EG^2$, because the pyramids are similar. Wherefore, the attraction of any one of the slices in the pyramid AB, upon a particle placed at A, is equal to the attraction of any one of the slices in EF upon a particle placed at E. Consequently, the whole attraction of the pyramid AB, is to the whole attraction of the pyramid EF, as the number of slices in AB to the number of slices in EF, that is, as the length AB to the length EF.

*Cor.* 1. The attractions of any portions of the pyramid, are as the lengths of the portions. For the attractions are proportional to the number of slices in the portions, that is, as the lengths.

*Cor.* 2. If the pyramids have different densities, their attractions are proportional to the lengths multiplied by the densities. For, in this case, the attraction of each slice will be proportional to its density: wherefore, the attractions will be as the densities multiplied by the number of slices; or, as the densities multiplied by the lengths.

8. *If there be two similar solids composed of the same homogeneous matter, which attracts in the inverse proportion of the square of the distance; any two particles of matter, similarly situated with regard to the solids, will be attracted by them with forces that are proportional to any of the homologous lines of the solids.*

Because the solids are similar, they may be resolved into an indefinitely great number of slender pyramids, and frustums of pyramids, that are similar to one another, and similarly placed in the solids; each pyramid having its vertex at one of the attracted particles. The direct attractions of any corresponding pair of pyramids will have constantly the same ratio to one another: for they will be as the lengths of the pyramids or frustums (7.); that is, because the solids are similar, as any two homologous lines of the solids. Wherefore, the whole attractive forces, compounded of all the direct attractions which act in directions that make the same angles with one another, will likewise have to one another the proportion of any two of the homologous lines of the solids.

*Cor.* If the two solids have different densities, their attractions will be proportional to the densities multiplied by any homologous lines of the solids (7. *Cor.* 2.).

9. *If there be two concentric elliptical spheroids that are similar and similarly situated, a particle placed anywhere within the inner surface will be in equilibrium, or will be urged equally in all opposite directions by the shell of homogeneous matter contained between the two surfaces, supposing the law of attraction to be that of the inverse proportion of the square of the distance.*

Let P (Plate XXX. fig. 5.) be a particle placed within such a shell, and let a slender double pyramid, having P for the common vertex, be extended to meet the surfaces of the solid on both sides of P. The portions of the pyramid, AGHB and CEFD between the surfaces on opposite sides of P, will have equal lengths (4.): wherefore, these portions will attract a particle placed at P with equal forces (7. *Cor.* 1.). The same thing may be proved of all the pyramids which have their vertices at P, and fill the spheroids. Wherefore, P is attracted equally in all opposite directions by the homogeneous matter contained between the surfaces of the spheroids.

10. *To find the attractive force of an indefinitely slender prism, acting in a direction parallel to the prism, upon a particle of matter placed anywhere.*

Attraction.

Let BC (Plate XXX. fig. 6.) be a prism of homogeneous matter, upon the indefinitely slender base CH, and let a particle of matter be placed at A; draw AB and AC to the extremities of the prism, and AE to any point in it; and draw AD perpendicular to BC. Let S = base CH, and put $AD = a$, $DE = x$; the element of the prism is $= S \times dx$; the element of the attraction in the direction AE, is $= \frac{S \times dx}{AE^2}$; and the element of the attraction in the direction parallel to the prism, is $= \frac{S \times dx}{AE^2} \times \frac{DE}{AE} = \frac{S \times x dx}{(a^2+x^2)^{\frac{3}{2}}}$.

Now, $\int \frac{S \times x dx}{(a^2+x^2)^{\frac{3}{2}}} = \text{Const.} - \frac{S}{\sqrt{a^2+x^2}} = \text{Const.} - \frac{S}{AE}$; and the constant quantity is determined by making the fluent begin at the end of the prism nearer to A: wherefore, the whole attractive force of the prism, in the direction parallel to the prism, is $= S \times \left\{\frac{1}{AB} - \frac{1}{AC}\right\}$.

*Cor.* In like manner may the attractive force of the prism be found, when the attraction of the particles is proportional to any function of the distance.

Let $AB = f$, $AC = f'$; suppose that $\varphi(f)$ is the function of the distance that expresses the law of attraction; and put $\int df. \varphi(f) = \Psi(f)$: then the attraction parallel to the prism, is =

$$S \times \pm \left\{\Psi(f) - \Psi(f')\right\},$$

observing that the attraction is always positive.

### Attraction of Spheres.

Attraction of Spheres.

11. *Spheres of the same homogeneous matter, attract particles placed on their surfaces, with forces proportional to their radii.*

Spheres being similar solid figures, this proposition is no more than a particular case of what was before proved (8.).

*Cor.* If the spheres have different densities, the attractions at their surfaces are proportional to their radii multiplied by their densities (8. Cor.).

12. *The force with which a particle, placed anywhere within a sphere of homogeneous matter, is urged towards the centre, is proportional to its distance from the centre.*

Conceive a concentric sphere to be described, which contains the attracted particle in its surface; the matter between the two surfaces will exert no force on the particle (9.), which will therefore be urged to the centre, only by the attraction of the inner sphere, in the surface of which it is placed: but this force is proportional to the radius of the sphere, or to the distance of the particle from the centre (11.).

13. *Let PNQ and ABC (fig. 7.) be two spheres of the same homogeneous matter, which attracts in the inverse proportion of the square of the distance: let the centres of the spheres be at M and D, and take MR equal to the radius of the sphere ABC, and ED equal to the radius of the sphere PNQ: the attractions of the spheres upon particles placed at R and E are to one another as the squares of the radii of the spheres.*

4

In the spheres draw two great circles perpendicular to the diameters PQ and AC, that pass through the points R and E; and let PpQ and AbC be two great circles, making equal indefinitely small angles NMp and BDb with the great circles PNQ and ABC. Let HK and FG, parallel to PQ and AC, be any two chords of the circles PpQ and AbC, that subtend similar arcs, or arcs containing the same number of degrees; and through HK and FG, let planes perpendicular to the circles PpQ and AbC, be drawn to cut the portions of the spheres contained in the angles NMp and BDb: join RH, RK, MH, MK, DF, DG, EF, EG. Because the arcs subtended by HK and FG, are like parts of their circumferences, it is plain, that the angle RMH = EDF, and RMK = EDG. And because ED = MH = MK, and RM = DF = DG (*hyp.*), therefore RH = EF, and RK = EG.

Conceive the chords HK and FG, together with the planes passing through them, to change their place a little, so as to describe two slender prisms, or elements of the portions of the spheres contained in the angles NMp and BDX. It is plain that MR and DO, the distances of the chords HG and FG from the centres of their circles, are constantly proportional to MN and DB, the radii of the spheres; wherefore RT and OS, the perpendicular sections of the small prisms, are similar figures, and have to one another the same ratio that $MX^2$ has to $DO^2$, or $MN^2$ to $DB^2$. Now, the attraction of the prism HK urging a particle at R to the centre M, is = $XT \times \left\{\frac{1}{RH} - \frac{1}{RK}\right\}$ (10.); and the attraction of the prism FG urging a particle at E to the centre D, is $= OS \times \left\{\frac{1}{EF} - \frac{1}{EG}\right\}$. But, in consequence of what was proved, $\frac{1}{RH} - \frac{1}{RK} = \frac{1}{EF} - \frac{1}{EG}$; wherefore the attractions of the prisms are to one another as XT to OS, or as $MN^2$ to $DB^2$.—The same thing may be proved of all the elements of the two portions of the spheres contained in the angles NMp and BDb; wherefore those portions attract particles at R and E with forces proportional to the squares of the radii of the spheres. But because the small angles NMp and BDb are equal, each of the spheres may be divided into an equal number of such portions; wherefore the attractions of the whole spheres upon particles placed at R and E, are proportional to the squares of the radii of the spheres.

*Cor.* This proposition is true, when the particles of matter attract one another with forces proportional to any proposed function of the distance.

Let $RH = EF = f$, and $RK = EG = f'$; then, adopting the same notation as before (8. *Cor.*), the attractions of the prisms urging particles placed at R and E to the centres M and D, are respectively $XTx \times \pm \left\{\Psi(f) - \Psi(f')\right\}$, and $OSx \times \pm \left\{\Psi(f) - \Psi(f')\right\}$: consequently, those attractions have the same pro-

Attraction. portion that RT has to SO, or $MN^2$ to $DB^2$. Wherefore the attractions of the whole spheres are in the same proportion.

14. *A particle placed anywhere without a sphere of homogeneous matter which attracts in the inverse proportion of the square of the distance, will be urged to the centre of the sphere, with a force that is inversely proportional to the square of the particle's distance from the centre.*

Let ABC (Plate XXX. fig. 8.) be the sphere, O its centre, and P a particle without the sphere: conceive a concentric sphere PMN, of the same homogeneous matter with the sphere ABC, to be described with the radius PO. Then, by the last proposition, the attraction of the sphere ABC upon the particle P, is to the attraction of the sphere PMN upon a particle placed at A, as $AO^2$ to $PO^2$. But the attraction of the sphere PMN upon a particle placed at A, is equal to the attraction of the sphere ABC upon the same particle; for the attraction of the matter between the two spherical surfaces exerts no force upon a particle at A (9.). Wherefore, in the proportion set down above, the two middle terms are constantly the same wherever the point P is placed without the sphere ABC. Consequently, the first term of the proportion must follow the inverse ratio of the last term; that is, the attraction of the sphere ABC upon the external particle at P is inversely proportional to $PO^2$.

15. *The same law of attraction being supposed, a homogeneous sphere will attract a particle placed without it, with the same force as if all the matter of the sphere were collected in the centre.*

Let $f$ denote the distance of the particle from the centre; then it follows, from the last proposition, that the attraction of the sphere upon the particle will have, for its measure, $\frac{A}{f^2}$; A denoting a constant quantity that will be determined by any particular case; that is, by the actual attractive force corresponding to any determinate distance from the centre. Let $r$ denote the radius of the sphere, and M its mass; then no part of the matter of the sphere being nearer the attracted particle than $(f-r)$, and none of it more remote than $(f+r)$, the attraction of the sphere on the particle will be greater than $\frac{M}{(f+r)^2}$, and less than $\frac{M}{(f-r)^2}$. Therefore $\frac{A}{f^2}$ is always contained between those limits, which requires that $A = M$. For, if A were greater than M, such values of $f$ might be found as would make $\frac{A}{f^2}$ equal to, or greater than $\frac{M}{(f-r)^2}$; and, if A were less than M, such values of $f$ might be found as would make $\frac{A}{f^2}$ equal to, or less than $\frac{M}{(f+r)^2}$. Therefore $A = M$; and the attraction of the sphere is equal to $\frac{M}{f^2}$, or the same as if all the matter were collected in the centre.

If the radius of the sphere $= r$, the density of the matter contained in it $= d$; then the mass, or $M = \frac{4\pi r^3 d}{3}$ ($\pi$ being the circumference of the circle whose diameter is unit), and the attraction of the sphere at the distance $f$ from the centre $= \frac{4\pi r^3 d}{3f^2}$. This is still true at the surface of the sphere when $f = r$, so that the attraction at the surface $= \frac{4\pi r d}{3}$; which expression, with the help of what is proved in (12.), enables us to compare the intensities of the attractions of homogeneous spheres, at all distances from the centre, without or within the surfaces.

*Cor.* 1. A shell of homogeneous matter contained between two concentric spherical surfaces, will attract a particle placed without it, with the same force as if all the matter of the shell were collected in its centre.

For the attractive force of such a shell is equal to the difference of the attractions of two concentric spheres of the same homogeneous matter with the shell.

*Cor.* 2. A sphere composed of concentric shells, that vary in their densities according to any law, will attract a particle placed without it, with the same force as if all the matter were collected in the centre.

For this having been proved of one shell (*Cor.* 1.), it must be true of any number of shells.

If $\varphi(r)$ denote the density at the distance $r$ from the centre, the quantity of matter in the sphere will be $= 4\pi . \int \varphi(r) . r^2 dr$; and the attraction on a particle without the sphere at the distance $f$ from the centre $= \frac{4\pi . \int \varphi(r) . r^2 dr}{f^2}$.

16. *Two spheres, each composed of concentric shells of variable density, attract one another with the same force as if all the matter of each were collected in its centre.*

For the attraction of a sphere A upon every particle of another sphere B will remain the same, if we suppose all the matter of A to be collected in its centre (15.). But the attraction of any particles of matter placed in A's centre, upon the sphere B, is equal and opposite to the attraction of B, upon the same matter so placed: and, again, the attraction of B upon all the particles placed in the centre of A, will remain unchanged, if we suppose the matter of B to be collected in its centre. Wherefore A attracts B with the same force as if the matter of each were collected in its centre.

17. *Supposing that the particles of matter attract with a force proportional to the distance, a body of any shape will attract a particle of matter placed anywhere with the same force, and in the same direction, as if all the matter of the body were collected in its centre of gravity.*

Suppose that the attracted particle is placed at P (fig. 9.), and the centre of gravity of the attracting body at G; join PG, and let any plane pass through that line. Let L be a small part, or element of the body, and

from L draw LK perpendicular to the plane passing through PG, and KF perpendicular to PG; join PL and PK. Put $dm$ to denote the quantity of matter, or the mass of the element L; then its attractive force, urging the particle in the direction PL, is $= PL \times dm$, which, by the resolution of forces, is equivalent to the two forces, $PK \times dm$ and $KL \times dm$; and, again, the single force $PK \times dm$ is equivalent to the two forces $FK \times dm$, and $PF \times dm = PG \times dm + GF \times dm$. Wherefore, the attraction of the element L, upon the particle at P, is equivalent to these four separate forces, viz. $PG \times dm$, $GF \times dm$, $FK \times dm$, $KL \times dm$, which urge the particle P respectively in the directions, PG, GF, FK, KL. But, from the nature of the centre of gravity, the sum of all the forces, $KL \times dm$, that urge the particle P to one side of the plane passing through PG, is just equal to the sum of the forces that urge it to the other side of the same plane; and the sum of all the forces, $FK \times dm$, that urge P to one side of the line PG, is just equal to the sum of the forces that urge it to the other side of the same line; and the sum of all the forces, $GF \times dm$, that urge P towards the point G, is just equal to the sum of the forces that urge it from the same point. Wherefore all the preceding forces mutually destroy one another, excepting the forces, $PG \times dm$, the sum of which, when extended to all the elements of the attracting body, is $= PG \times$ mass of the body. Wherefore the whole attraction upon P is the same as if all the matter of the body were collected in its centre of gravity.

*Cor.* Supposing that the particles of matter attract with a force proportional to the distance, a homogeneous sphere will attract a particle placed anywhere in the same manner as if all the matter of the sphere were collected in the centre.

For the centre of gravity of a homogeneous sphere, is the same as the centre of its figure. This corollary is likewise true of a sphere composed of concentric shells of variable density; and it is easy to apply the demonstration of (16.) to prove that, in this law of attraction, two spheres, each composed of concentric shells of variable density, will attract one another with the same force as if the matter of each were collected in its centre.

18. *To investigate what are the laws of attraction, in regard to the distance, according to which a shell of homogeneous matter, contained between two concentric spherical surfaces, will attract a particle placed without it, in the same manner as if all the matter of the shell were collected in the centre.*

It has been proved that this property actually belongs to homogeneous shells in the law of attraction which obtains in nature, and likewise when the particles of matter attract with a force proportional to the distance; but it is interesting to know whether it is confined to these two cases alone, or extends to other laws of attraction. This can only be discovered by a direct analysis.

Let $r = PC$ (fig. 10.), the distance of the attracted point from the centre of the shell; $u = CA$ the radius of the inner surface of the shell; $f = PM$, the distance of P from any point in the surface. Having drawn the diameter AD through P, let AMD and AND be two great circles, making, with one another, an indefinitely small angle $MAN = dq$; and let two small circles BMG, $bmg$, indefinitely near one another, of which A and D are the poles, meet the former circles in M, N, $m$, $n$; and draw MS, NS to the centre of the circle BMG. Put $\theta$ for the measure of the arc AM; then $MS = u \sin. \theta$; $MN = dq \,.\, u \sin. \theta$; $Mm = ud\theta$; and the quadrilateral space $MNnm = u^2.dq.d\theta \sin.\theta$. We may suppose the thickness of the shell indefinitely small; since, if the property belong to an elementary shell indefinitely thin, it will be true of one of a determinate thickness, which can be resolved into such elements. Suppose the thickness of the shell to be $= du$; then, the quantity of matter in the part standing upon the quadrilateral space $MNnm = u^2du.dq.d\theta \sin. \theta$. Let $\varphi(f)$ represent the direct attraction of a particle at M in the direction PM; then its attraction directed to the centre $C = \varphi(f) \times \frac{PS}{PM} = \frac{r - u\cos.\theta}{f} \times \varphi(f)$;

and the attraction of the element of the shell in the same direction $= u^2du \,.\, dq \,.\, d\theta \sin.\theta \times \frac{r - u\cos.\theta}{f} . \varphi(f)$.

This expression is proportional to $dq$, when $\theta$ and $f$ remain constant; and, therefore (denoting by $\pi$ the circumference of the circle whose diameter is unit), the attraction of the whole zone contained between the small circles BMG, $bmg$, will be $= 2\pi . u^2du \,.\, d\theta \sin.\theta . \frac{r - u \cos.\theta}{f} . \varphi(f)$: and the attractive force of the whole shell will be

$$2\pi . u^2du \int d\theta \sin.\theta \,.\, \frac{r - u\cos.\theta}{f} . \varphi(f);$$

the fluent to be extended from $\theta = 0$ to $\theta = \pi$.

Again, the quantity of matter in the shell is $= 4\pi \,.\, u^2du$; and the attraction of this matter placed in the centre, at the distance $r$ from P, is $= 4\pi . u^2du . \varphi(r)$.

If now we equate the attraction of the shell, to the attraction of its matter placed in the centre, and leave out the factors common to both, we shall get

$$2\varphi(r) = \int d\theta \sin.\theta \,.\, \frac{r - u\cos.\theta}{f} . \varphi(f)$$

the limits of the integral being the same as before.

But $f^2 = r^2 - 2ru \cos. \theta + u^2$; then $d\theta \sin. \theta = \frac{fdf}{ru}$; also $r - u \cos. \theta = \frac{f^2 + r^2 - u^2}{2r}$: wherefore, by substitution, we get

$$4 \,.\, r^2\varphi(r) \,.\, u = \int (f^2 + r^2 - u^2) \,.\, df \,.\, \varphi(f);$$

or, which is equivalent, $4.r^2\varphi(r) \,.\, u =$

$(f^2 + r^2 - u^2) \,.\, \int df \,.\, \varphi(f) - 2 \int fdf \int df \,.\, \varphi(f)$,

the limits of this integral being from $f = r - u$ to $f = r + u$, which correspond to $\theta = 0$ and $\theta = \pi$.

Now let $\int df . \varphi(f) = \Psi(f)$; and $\int fdf \int df . \varphi(f) = \int fdf . \Psi(f) = \Psi'(f)$: then, by taking the fluents between the proper limits, we get

Attraction.

$$4.r^2\varphi(r).u = 2r.\left\{(r+u)\Psi(r+u)-(r-u)\Psi(r-u)\right\}$$
$$-2\left\{\Psi'(r+u)-\Psi'(r-u)\right\}.$$

If we develope the binomial functions in the last expression, all the even powers of $u$ will disappear, and the odd powers only will remain; these last terms being all contained in this general formula,

$$\text{viz. } \frac{4}{1.2.3\ldots 2n+1}.$$
$$\left\{r.\frac{d^{2n+1}\, r\Psi(r)}{dr^{2n+1}}-\frac{d^{2n+1}\,\Psi'(r)}{dr^{2n+1}}\right\}.u^{2n+1};$$

and, observing that $\frac{d.\Psi'(r)}{dr}=r\Psi(r)$, the same expression will become $\frac{4}{1.2.3\ldots.2n+1}$.

$$\left\{r.\frac{d^{2n+1}\, r\Psi(r)}{dr^{2n+1}}-\frac{d^{2n}\, r\Psi(r)}{dr^{2n}}\right\}.u^{2n+1};$$

which, again, is more simply expressed thus, viz.

$$\frac{4r^2}{1.2.3\ldots.2n+1}.\frac{d.\left\{\frac{1}{r}.\frac{d^{2n}r\Psi(r)}{dr^{2n}}\right\}}{dr}.u^{2n+1}.$$

Wherefore, by substituting the developement instead of the functions, and then, by dividing by $4\,r^2\,u$, we get

$$\varphi(r)=\frac{d.\Psi(r)}{dr}+\frac{1}{1.2.3}.\frac{d.\left\{\frac{1}{r}.\frac{d^2 r\Psi(r)}{dr^2}\right\}}{dr}.u^2$$
$$+\frac{1}{1.2.3.4.5}.\frac{d.\left\{\frac{1}{r}.\frac{d^4 r\Psi(r)}{dr^4}\right\}}{dr}.u^4$$
$$+\ \&c.$$

From the nature of the function $\Psi(r)$, we get $\varphi(r) = \frac{d.\Psi(r)}{dr}$; wherefore each of the remaining terms must be separately equal to nothing: Hence

$$d.\left\{\frac{1}{r}.\frac{d^2\, r\,\Psi(r)}{d\,r^2}\right\}=0;$$

from which we find $r\,\Psi(r)=\frac{1}{2}\,A\,r^3+A'r-A''$, $A, A', A''$ being arbitrary constant quantities; and this value of $r\,\Psi(r)$, it is plain, will likewise render all the succeeding terms of the developement evanescent. Wherefore

$$\varphi(r)=\frac{d.\Psi(r)}{dr}=A\,r+\frac{A''}{r^2}.$$

Thus the most general expression of the law of attraction, that possesses the property in question, is a combination of the two laws above mentioned, with each of which it coincides, according as we make the one or other of the constant quantities equal to nothing. We have therefore a direct proof, that the law of nature is the only one which will make the attraction decrease as the distance increases, and in which a spherical shell, or a sphere, will attract in the same manner as if all the matter were collected in the centre.

Laplace has arrived at the same conclusion by a different process. (*Mech. Celeste*, Liv. 2d. Chap. 2. No. 12. Rem. Part.)

### ATTRACTION OF SPHEROIDS OF REVOLUTION.

Attraction of Spheroids of Revolution.

19. *Let APBQ (Plate XXXI. fig. 11.) and CMDN be two concentric ellipses, similar to one another, and similarly situated, of which AB and CD are either the greater, or less, axes; and let PCQ be perpendicular to AB. Conceive the ellipses to revolve about PQ, so as to describe an indefinitely small angle; then, supposing the law of attraction to be inversely proportional to the square of the distance, the thin solid of homogeneous matter described by the ellipse APBQ, will attract a particle placed at P, in a direction perpendicular to any plane passing through PQ, with the same force that the thin solid of the same matter described by the ellipse CMDN, will attract a particle placed at C perpendicularly to the same plane.*

From C draw CM, CN, making equal angles with CD, and PR, PT respectively parallel to CM, CN; and let C$m$, C$n$, P$r$, P$t$, be drawn in the same manner, and indefinitely near the former lines. While the ellipses revolve about PQ, the small sectors will describe pyramids that have their vertices at C and P. It is manifest that the pyramids so described are similar: for their angles at C and P in the planes of the ellipses are equal; and their other angles described by revolving about PQ are likewise equal, because the sectors are equally inclined to that axis. Wherefore, the direct attractions of all the small pyramids upon the particles P and C, are proportional to the lengths PR, PT, CM, CN (7); and consequently the forces that urge the particles P and C in a direction at right angles to any plane passing through PQ, are proportional to the perpendiculars let fall upon that plane from R, T, M, N. But, because PR, PT, CM, CN are equally inclined to PQ, they will make equal angles with any plane passing through PQ: wherefore the perpendiculars drawn to the plane from R, T, M, N, will be respectively proportional to CM, CN, PR, PT. But CM + CN = PR + PT (6.): wherefore, the sum of the perpendiculars drawn to the plane from M and N, will be equal to the sum of the perpendiculars drawn to it from R and T. Consequently the force of the pyramids PR and PT, which urges the particle P at right angles to the plane, is equal to the force of the pyramids CM and CN, which urges the particle C in a parallel direction. The same thing is true of all the small pyramids that make up the thin solids described by the ellipses APBQ and CMDN; and it is therefore true of the whole solids.

It is to be observed, that when the pyramids PR and PT fall on opposite sides of PQ, it is the difference of their attractions which is equal to the sum of the attractions of CM and CN: and it is the difference of the perpendiculars let fall from T and R on opposite sides of the plane, which is equal to the sum of the perpendiculars let fall from M and N.

20. *Let APBQ be a spheroid of revolution, PQ the axis of revolution, and ACB a plane through the centre perpendicular to PQ (Plate XXXI. fig. 12.). If D be a particle in the surface of the spheroid, and DL perpendicular to the plane ACB; then the attraction of the spheroid on a particle placed at the pole P, will be to the force with which a particle placed at C, is attracted in the direction DL, as PC is to DL.*

Through D draw a plane parallel to the plane ACB, and let the plane so drawn cut the axis PQ in F: draw the straight line DFE to terminate in the spheroid, and describe another spheroid through F, having the same centre with the spheroid APBQ, and similar to it, and similarly situated. Conceive an indefinitely great number of planes, making indefinitely small angles with one another, to be drawn through DE, so as to divide the two spheroids into an indefinitely great number of thin solids, or slices: then the sections which every one of the planes make with the spheroids will be similar ellipses, having the same centre (5.); and it is manifest that a straight line drawn through F at right angles to DE, in any one of the planes, will pass through the centre of the two ellipses contained in it, and will coincide with an axis of each. Wherefore, the force with which every one of the slices, or elements, of the spheroid APBQ attracts a particle placed at D in the direction DL, is equal to the force with which the corresponding slice, or element, of the spheroid GFHK, attracts a particle placed at F in the direction FC (19.). Wherefore, the whole attraction of the spheroid APBQ upon a particle at D, in the direction DL, is equal to the whole attraction of the spheroid GFHK, upon a particle at F. But the attractions of the spheroids APBQ and GFHK, upon particles placed at P and F, are to one another as PC to FC (8.). Wherefore, the attraction of the spheroid APBQ upon a particle at P, is to the force with which the same spheroid attracts a particle at D, in the direction DL, as PC is to FC or DL.

21. *Let APBQ be a spheroid of revolution, and PQ the axis of revolution, as before. If D be a particle in the surface, ADPB (fig. 13.) a section through D, and the axis PQ, and DL perpendicular to PQ; the attraction of the spheroid upon a particle at A, will be to the force with which a particle at D is attracted, in the direction DL, as AC is to DL.*

Through D draw a plane perpendicular to AB, which cuts the section ADB in the straight line DFE; and let a spheroid FGHK be described through F, having the same centre with the spheroid APBQ, and similar to it, and similarly situated. Then, conceiving the two spheroids to be divided into an indefinitely great number of thin slices by planes passing through DE, the force with which every slice, or element, of the spheroid APBQ attracts a particle at D in the direction DL, will be equal to the force with which the corresponding slice, or element, of the spheroid FGHK attracts a particle at F (19.). But the attractions of the spheroids APBQ and FGHK upon particles placed at A and F, are to one another as AC to CF (8.). Wherefore, the attraction of the spheroid APBQ upon a particle at A, is to the force with which the same spheroid attracts a particle at D, in the direction DL, as AC to FL or DL.

The two last propositions will enable us to find both the direction and the intensity of the attraction of a homogeneous spheroid of revolution upon a particle placed anywhere on the surface, when we have ascertained the attractive forces at the poles, and at the circumference of the circular section made by a plane through the centre perpendicular to the axis. For the whole attraction at any point, is the compound force arising from the attractions perpendicular to the axis, and parallel to it. The next object of our research is, therefore, to determine the two forces above-mentioned, viz. the attraction at the poles, and at the circular section, equally distant from both poles.

22. *Let ABD be an indefinitely slender pyramid, of which the base BD is perpendicular to the edge AD (fig. 14.): let B = base BD, and f = length AD; then $\frac{B}{f}$ = the attraction of the whole matter of the pyramid upon a particle placed at the vertex A.*

Let AM $= x$; then the section MN parallel to the base BD $= \frac{B.x^2}{f^2}$; and, MP = element of the prism $= \frac{B.x^2 dx}{f^2}$; and the attraction of the element upon a particle placed at A $= \frac{MP}{AM^2} = \frac{B.dx}{f^2}$: the fluent of which is $= \frac{Bx}{f^2}$ = attraction of the pyramid AM upon a particle at A. And, when $x = f$, this becomes $= \frac{B}{f}$ = attraction of the pyramid AD upon a particle placed at A.

23. *To investigate the attraction of a homogeneous spheroid of revolution, upon a particle placed at the pole.*

Let P (fig. 15.) be the pole, PCQ the axis of revolution, and APBQ a section of the spheroid by a plane passing through PQ, and any point M, in the surface; draw PM, P$m$ indefinitely near PM, and M$m$ perpendicular to P$m$. Conceive the plane PMQ to revolve about PQ, so as to describe the indefinitely small angle BCO; then the small triangle MP$m$ will describe a slender pyramid, having its vertex at P, and of which the base is a rectangle, contained by M$m$ and RT; for the point M moving parallel to R, it will describe a line equal and parallel to that described by R, namely, to RT.

Let PM $= f$; and the angle KPM, which PM makes with a perpendicular to the axis, $= \theta$; and the indefinitely small angle BCO $= d\varphi$. Then M$m = f d\theta$; RT $=$ CR $\times d\varphi = f \cos.\theta . d\varphi$; and B, the base of the slender pyramid described by the triangle MP$m$, $= d\varphi . d\theta \cos.\theta . f^2$: wherefore, the direct attraction of the pyramid on a particle at P $= \frac{B}{f}$ (22) $=$

Attraction. $d\varphi . d\theta \cos.\theta . f$; and the elementary attraction of the spheroid in the direction PC = direct attraction of the pyramid $\times \frac{PS}{PM} = d\varphi . d\theta \cos.\theta \sin.\theta . f$.

Again, let MR $= x$, CR $= y$, PC $= k$, AC $= k'$; then $y = f \cos.\theta$; $x = k - f \sin.\theta$; if we substitute these values in the equation of the solid (1.), we get

$$\frac{(k - f\sin.\theta)^2}{k^2} + \frac{f^2 \cos.^2\theta}{k'^2} = 1;\text{ whence}$$

$$f = \frac{2k'^2 k}{k^2} \cdot \frac{\sin.\theta}{\cos.^2\theta + \frac{k'^2}{k^2}\sin.^2\theta}.$$

By substituting the value of $f$ just found in the preceding expression of the elementary attraction of spheroid, it will become

$$\frac{2k'^2 k.}{k^2} d\varphi \cdot \frac{d\theta \cos.\theta . \sin.^2\theta}{\cos.^2\theta + \frac{k'^2}{k^2}\sin.^2\theta};$$

which must be integrated from $\varphi = o$ to $\varphi = 2\pi$; and from $\theta = o$ to $\theta = \frac{\pi}{2}$; $\pi$ denoting always the half-circumference when radius is unit.

In an oblate spheroid $k$ is less than $k'$; put $k'^2 - k^2 = k^2 . e^2$, and $z = \sin.\theta$; then the element of the attractive force will become, by substitution,

$$\frac{2\,k'^2 k.}{k^2} d\varphi \cdot \frac{z^2 dz}{1 + e^2 z^2} = \frac{2\,k'^2 k . d\varphi}{k^2 e^3} \cdot \left\{ e dz - \frac{edz}{1 + e^2 z^2} \right\};$$

and by integrating from $z = o$ to $z = 1$, we get,

$$\frac{2k'^2 k . d\varphi}{k^2 e^3} \cdot \left\{ e - \text{arc. tan. } e \right\};$$

for the force with which the matter between the planes PBQ and POQ urges the particle P to the centre. Wherefore the whole attractive force of the spheroid upon a particle at P is =

$$\frac{4\pi . k'^2 k}{k^2 e^3} \cdot \left\{ e - \text{arc. tan. } e \right\};$$

And, because $\frac{4\pi . k'^2 k}{3}$ = mass of the spheroid = M, we get the measure of the attraction of the oblate spheroid upon a particle placed at the pole, equal to

$$k . \frac{3\,M}{k^3 e^3} \cdot \left\{ e - \text{arc. tan. } e \right\}.$$

In an oblong spheroid, $k$ is greater than $k'$; put $k^2 - k'^2 = k^2 e^2$; then the element of the attractive force will become, by substitution,

$$\frac{2k'^2 k.}{k^2} d\varphi \cdot \frac{z^2 dz}{1 - e^2 z^2} = \frac{2\,k'^2 k . d\varphi}{k^2 e^3} \left\{ \frac{edz}{1 - e^2 z^2} - edz \right\}:$$

whence, by proceeding as before, we get the measure of the attractive force of the oblong spheroid on a particle placed at the pole, equal to

$$k . \frac{3\,M}{k^3 e^3} \cdot \left\{ \frac{1}{2}\text{hyp.log.}\frac{1+e}{1-e} - e \right\}.$$

*Cor.* In an oblate spheroid differing little from a sphere, $e^2$ will be a very small fraction, of which we may reject the higher powers. When this is done, the preceding expression of the polar attraction, viz.

$$\frac{4\pi . kk'^2}{k^2 e^3} \cdot (e - \text{arc. tan. } e),$$

will be $= 4\pi k . \ (1 + e^2)(\frac{1}{3} - \frac{1}{5}e^2) = \frac{4\pi k}{3} \cdot \left(1 + \frac{2}{5}e^2\right)$.

And, if $k' = k + \tau = k\sqrt{1 + e^2}$, be the radius of the equator, then $2\frac{\tau}{k} = e^2$: so that the attraction at the pole will be

$$\frac{4\pi k}{3} \cdot \left(1 + \frac{4}{5} \cdot \frac{\tau}{k}\right).$$

24. *To investigate the attraction of a homogeneous spheroid of revolution, on a particle placed in the circumference of the circular section, made by a plane through the centre, at right angles, to the axis of revolution.*

Let P (Plate XXXI. fig. 16.) be the pole, PC the axis of revolution. A, a point in the circular section AOB, made by a plane through the centre perpendicular to PC. Let M be any point in the surface of the spheroid; AMO a section through A and M by a plane perpendicular to AOB; A$m$ a line in that plane indefinitely near AM, and M$m$ perpendicular to A$m$; MR perpendicular to AO, and RS to AB. Conceive the plane AMO to revolve about A, so as to describe an indefinitely small angle OAQ; then the triangle AM$m$ will describe a slender pyramid, having its vertex at A, and of which the base is equal to a rectangle contained by M$m$ and RT; for the point M moving parallel to the point R, it will describe a line equal to that described by R, namely to RT.

Let AM $= f$; the angle MAR $= \theta$; and the angle OAQ $= d\varphi$: then M$m$ $= fd\theta$; and TR = AR $\times\, d\varphi = f\cos.\theta . d\varphi$: Wherefore, B = base of the pyramid described by MA$m$ $= d\varphi . d\theta \cos.\theta . f^2$: and the direct attraction of the pyramid in the direction AM $= \frac{B}{f}$(22.) $= d\varphi . d\theta \cos.\theta . f$. Wherefore, the elementary attraction of the spheroid, in the direction AC = direct attraction of the pyramid $\times \frac{AR}{AM} \times \frac{AS}{AR} = d\varphi \cos.\varphi . d\theta \cos.^2\theta . f$.

Again, let MR $= x$, RS $= y$, CS $= z$, CP $= k$ and AC $= k'$; then (1.)

$$\frac{x^2}{k^2} + \frac{y^2 + z^2}{k'^2} = 1.$$

But $x = f\sin.\theta$; $y = \text{AR} . \sin.\varphi = f\cos.\theta\sin.\varphi$; and $z = k' - f\cos.\theta\cos.\varphi$: wherefore, by substitution, we get

$$\frac{f^2\sin.^2\theta}{k^2} + \frac{f^2\cos.^2\theta\sin.^2\varphi}{k'^2} + \frac{(k' - f\cos.\theta\cos.\varphi)^2}{k'^2} = 1.$$

From this equation we get

$$f = 2k' . \frac{\cos.\theta\cos.\varphi}{\cos.^2\theta + \frac{k'^2}{k^2}\sin.^2\theta}.$$

Let this value of $f$ be substituted in the expression of the elementary attraction of the spheroid before found, and it will become

$$2k' . d\varphi \cos.^2 \varphi . \frac{d\theta \cos.^3\theta}{\cos.^2\theta + \frac{k'^2}{k^2}\sin.^2\theta} :$$

which expression, when integrated from $\varphi = o$ to $\varphi = \pi$, and from $\theta = o$ to $\theta = \frac{1}{2}\pi$, will give the attraction of half the spheroid: and the double of it, viz.

$$4k' . d\varphi \cos.^2 \varphi . \frac{d\theta \cos.^3\theta}{\cos.^2\theta + \frac{k'^2}{k^2}\sin.^2\theta},$$

being integrated between the same limits, will give the whole attraction of the spheroid.

In the oblate spheroid, $k$ is less than $k'$: Let $k'^2 - k^2 = k^2e^2$, and $z = \sin. \theta$: and, by substitution, the element of the attractive force will become

$$4k' . d \cos.^2\varphi . \frac{dz(1-z^2)}{1+e^2z^2} =$$

$$4k' . d\varphi \cos.^2 \varphi . \frac{1+e^2}{e^3} . \left\{\frac{edz}{1+e^2z^2} - \frac{edz}{1+e^2}\right\}.$$

And, by integrating from $z = o$ to $z = 1$, we get

$$4k' . d\varphi \cos. \varphi . \frac{1+e^2}{e^3} . \left\{\text{arc. tan.}\, e - \frac{e}{1+e^2}\right\},$$

for the force with which the matter between the sections that contain the angle OAQ, attracts the particle A to the centre. But $\int d\varphi \cos.^2 \varphi = \int\frac{d\varphi}{2} . (1+\cos.^2\varphi) = \frac{\varphi}{2} + \frac{1}{4}\sin. 2\varphi$; the value of which, between the limits $\varphi = o$, and $\varphi = \pi$, is $= \frac{\pi}{2}$: wherefore, the attraction of the spheroid on a particle at A, is equal to

$$2\pi . k' \frac{1+e^2}{e^3} . \left\{\text{arc. tan.}\, e - \frac{e}{1+e^2}\right\}.$$

Because $\frac{4\pi . k'^2 k}{3} = \frac{4\pi . k^3 . (1+e^2)}{3} = M$; we get $2\pi . (1+e^2) = \frac{3\,M}{2k^3}$: wherefore, the measure of the attractive force of the oblate spheroid on a particle placed anywhere in the circumference of the circular section made by a plane through the centre at right angles to the axis, is equal to

$$k' . \frac{3\,M}{2k^3 . e^3} . \left\{\text{arc. tan.}\, e - \frac{e}{1+e^2}\right\}.$$

In the oblong spheroid, $k$ is greater than $k'$; put $k^2 - k'^2 = k^2 . e^2$: then the element of the attractive force will become, by substitution,

$$4k'\ d\varphi \cos.^2\varphi . \frac{dz\,(1-z^2)}{1-e^2z^2} = 4k' . d\varphi \cos.^2\varphi . \frac{1-e2}{e^3} .$$

$$\left\{\frac{edz}{1-e^2} - \frac{edz}{1-e^2z^2}\right\}:$$

whence, by proceeding as before, we get the measure of the attractive force of the oblong spheroid upon a particle placed anywhere in the circumference of the circular section, made by a plane through the centre at right angles to the axis, equal to

$$k' . \frac{3M}{2k^3 . e^3} . \left\{\frac{e}{1-e^2} - \frac{1}{2}\,\text{hyp. log.}\, \frac{1+e}{1-e}\right\}.$$



*Cor.* In an oblate spheroid, differing little from a sphere, the higher powers of $e^2$ may be neglected. The expression of the attractive force at the equator, viz. $2\pi . k' . \frac{1+e^2}{e^3} . \left\{\text{arc. tan.}\, e - \frac{e}{1+e^2}\right\}$ will then become

$$2\pi . k' . (1+e^2)\left(\frac{2}{3} - \frac{4}{5}e^2\right) = \frac{4\pi k'}{3} . (1 - \frac{1}{5}e^2).$$

And if $k'$, the radius of the equator, $= k + \tau$; then $\frac{2\tau}{k} = e^2$ (23. *Cor.*); and the attraction at the equator will be equal to

$$\frac{4\pi k}{3} . \left(1 + \frac{\tau}{k}\right) . \left(1 - \frac{2}{5} . \frac{\tau}{k}\right) = \frac{4\pi k}{3} . \left(1 + \frac{3}{5} . \frac{\tau}{k}\right).$$

25. *An oblate spheroid of revolution being given, it is required to find the measures of the attractive forces that urge a particle placed anywhere in the surface, in a direction perpendicular to the axis, and in a direction parallel to it.*

Let $k$ and $k'$ be the semiaxes of the ellipse by the revolution of which the spheroid is described, $k$ being the axis about which it revolves: and let $b$ be the perpendicular distance of the particle from the axis, and $a$ its distance from the plane, drawn through the centre at right angles to the axis: Then, from which was proved in (20.) and (21.), the attractions sought will be found by multiplying the attractions at the pole, and at the circular section equally distant from both poles, by $\frac{a}{k}$ and $\frac{b}{k'}$.

Thus we get the attraction in the direction of $a$, equal to

$$a \times \frac{3M}{k . e^3}\ \left\{e - \text{arc. tan.}\, e\right\};$$

and the attraction in the direction of $b$, equal to

$$b \times \frac{3M}{2k^3 . e^3} . \left\{\text{arc. tan.}\, e - \frac{e}{1+e^2}\right\}.$$

The same formulæ likewise serve for finding the attractions upon a particle placed anywhere within the spheroid. For the attraction upon a particle within the spheroid is equal to the attraction of a similar concentric spheroid, which contains the particle in its surface (9.); and it is evident, that the coefficients, which multiply $a$ and $b$ in the above expressions, depend only upon the proportion of $k$ and $k'$; and they are therefore the same for all similar spheroids.

If we denote by A and B the coefficients of $a$ and $b$ in the expressions of the attractive force found above, the whole attraction of the spheroid, which is compounded of the forces $a$ . A and $b$ . B, will be $= \sqrt{a^2 A^2 + b^2 B^2}$. And if $\Psi$ denote the angle which the direction of this force makes with $a$, or with the axis of the spheroid; then $\tan. \Psi = \frac{b.B}{a.A}$.

*Cor.* In the very same manner we may determine the attractions of an oblong spheroid of revolution, upon a point in the surface, or within the solid.

26. *If $k$, $k'$, $k''$, the semiaxes of a homogeneous ellipsoid, be related to those of another ellipsoid of the same matter, $h$, $h'$, $h''$, so that $k'^2-k^2=h'^2-h^2$ and $k''^2-k^2=h''^2-h^2$, the attractions perpendicular to the planes of the principal sections, which the first ellipsoid (Plate XXXI. fig. 17.) exerts upon a point determined by the coordinates $h \sin. m$, $h' \cos. m \sin. n$, $h'' \cos. m \cos. n$. respectively parallel to $k$, $k'$, $k''$, will be to the attractions which the second ellipsoid exerts upon a point determined by the coordinates $k \sin. m$. $k' \cos. m \sin. n$, $k'' \cos. m \cos. n$, respectively parallel to $h$, $h'$, $h''$, in the direct proportion of the areas of the principal sections to which the attractions are perpendicular.*

This proposition is an extension to all elliptical spheroids of what was proved of the sphere in (13.). It is here enunciated of the ellipsoid, because the demonstration is not more difficult for that solid than for spheroids of revolution.

Let ABDM be an ellipsoid, the semiaxes of which are $BC=k$, $EC=k'$, and $AC=k''$; and *acdm* another ellipsoid, of which the semiaxes are, $bc=h$, $ec=h'$, and $ac=h''$; those quantities being so related, that $k'^2-k^2=h'^2-h^2$, and $k''^2-k^2=h''^2-h^2$. Also, let G be a point about the ellipsoid ABDM, so determined that GH, parallel to BC, $=h \sin. m$; HK, parallel to CE, $=h' \cos. m \sin. n$; and $CK=h'' \cos. m \cos. n$; and let $g$ be a point about the ellipsoid *abdm*, so determined that $gh$, parallel to $bc$, $=k \sin. m$; $hk$, parallel to $ce$, $=k' \cos. m \sin n$; and $ck=k'' \cos. m \cos. n$. Then the force with which the ellipsoid ABDM attracts a particle placed at G in the direction GH, will be to the force with which the ellipsoid *abdm* attracts a particle placed at $g$ in the direction $gh$, as the area of the section AEDM to the area of the section *aedm*, or as $k' k''$ to $h' h''$.

Let $RP=k \sin. \theta$; $PO=k' \cos. \theta \sin. \varphi$; and $CO=k'' \cos. \theta \cos. \varphi$; which suppositions are allowable, because they satisfy the equation of the ellipsoid (1.), whatever be the angles $\theta$ and $\varphi$. Draw CPM through the centre, and CN indefinitely near it; then $CP=\cos. \theta \sqrt{k'^2 \sin.^2 \varphi + k''^2 \cos.^2 \varphi}$; and when $\cos. \theta = 1$, $CM=\sqrt{k'^2 \sin.^2 \varphi + k''^2 \cos.^2 \varphi}$: wherefore $\frac{CP}{CM}=\cos. \theta$. Let the angle $DCM=\Psi$; then $\tan. \Psi = \frac{PO}{CO} = \frac{k'}{k''} \tan. \varphi$; and, by taking the fluxions, $\frac{d\Psi}{\cos.^2 \Psi} = \frac{k'}{k''} \cdot \frac{d\varphi}{\cos.^2 \varphi}$; but $\frac{1}{\cos.^2 \Psi} = 1 + \tan.^2 \Psi = \frac{k'^2 \sin.^2 \varphi + k''^2 \cos.^2 \varphi}{k''^2 \cos.^2 \varphi} = \frac{CM^2}{k''^2 \cos.^2 \varphi}$; wherefore $d\Psi \cdot CM^2 =$ twice the sector $MCN = k' k'' . d\varphi$.

And, in like manner, in the other ellipsoid, if $rp = h \sin. \theta$; $po=h' \cos. \theta \sin. \varphi$; and $co=h'' \cos. \theta \cos. \varphi$: then $\frac{cp}{cm}=\cos. \theta$, and twice the sector $mcn = h' h'' d\varphi$.

It is plain, from what has been shown, that, when $\theta$ varies, and $\varphi$ remains constant in the expressions of the coordinates, the points P and $p$ will move along CM and $cm$, so that, in every position, $\frac{PC}{MC} = \frac{pc}{mc}$.

Let Q and $q$ be indefinitely near P and $p$; and through P and Q draw lines parallel to MN; and through $p$ and $q$ draw lines parallel to $mn$. Let S denote the quadrilateral contained between the parallels drawn through P and Q; and S′ that contained between the lines drawn through $p$ and $q$: Then $\frac{S}{MCN} = \frac{QC^2 - PC^2}{MC^2}$; and $\frac{S'}{MCN} = \frac{qc^2 - pc^2}{mc^2}$; wherefore, since $\frac{PC}{MC} = \frac{pc}{mc}$, and $\frac{QC}{MC} = \frac{qc}{mc}$, it is manifest that $\frac{S}{S'} = \frac{MCN}{mcn} = \frac{k' k''}{h' h''}$.

Upon the quadrilaterals S and S′ let upright prisms RS and $rs$ be erected, and be prolonged to meet the surfaces of the spheroids; join GR, GS, $gr$, $gs$. Then,

$$GR^2 = (h \sin. m - k \sin. \theta)^2 + (h' \cos. m. \sin. n - k' \cos. \theta \sin. \varphi)^2. + (h'' \cos. m \cos. n - k'' \cos. \theta \cos. \varphi)^2;$$

$$g r^2 = (k \sin. m - h \sin. \theta)^2 + (k' \cos. m \sin. n - h' \cos. \theta \sin. \varphi)^2. + (k'' \cos. m \cos. n - h'' \cos. \theta \cos. \varphi)^2:$$

And, by expanding these expressions, we get

$$GR^2 = \Big\{ (h^2 + (h'^2 - h^2) \cos.^2 m \sin.^2 n + (h''^2 - h^2) \cos.^2 m \cos.^2 n) + (k^2 + (k'^2 - k^2) \cos.^2 \theta \sin.^2 \varphi + (k''^2 - k^2) \cos.^2 \theta \cos.^2 \varphi) - 2 (hk \sin. m \sin. \theta + h' k' \cos. m \cos. \theta \sin. n \sin. \varphi + h'' k'' \cos. m \cos. \theta \cos. n \cos. \varphi) \Big\};$$

$$gr^2 = \Big\{ (k^2 + (k'^2 - k^2) \cos.^2 m \sin.^2 n + (k''^2 - k^2) \cos.^2 m \cos.^2 n) + (h^2 + (h'^2 - h^2) \cos.^2 \theta \sin.^2 \varphi + (h''^2 - h^2) \cos.^2 \theta \cos.^2 \varphi) - 2 (hk \sin. m \sin. \theta + h' k' \cos. m \cos. \theta \sin. n \sin. \varphi + h'' k'' \cos. m \cos. \theta \cos. n \cos. \varphi) \Big\}.$$

These expressions are equal, because $k'^2 - k^2 = h'^2 - h^2$, and $k''^2 - k^2 = h''^2 - h^2$: wherefore $RG = rg = f$. And, in like manner, it is shown, that $GS = gs = f'$.

Now, the attraction of the prism RS urging a particle at G in the direction GH, is equal to $S \times \left\{ \frac{1}{f} - \frac{1}{f'} \right\}$ (10); and the attraction of the prism $rs$ urging a particle at $g$ in the direction $gh$, is $= S' \times \left\{ \frac{1}{f} - \frac{1}{f'} \right\}$: wherefore these attractions

are to one another as S to S′, or as $k'k''$ to $h'h''$. The same thing may be proved of all the elementary prisms that make up the two portions of the spheroids contained between the planes BCM, BCN, and *bcm*, *bcn* : wherefore, those portions attract particles at G and *g*, with forces proportional to $k'k''$ and $h'h''$. But the two spheroids may be divided into an equal number of such portions: wherefore the spheroids attract particles placed at G and *g*, in the directions GH and *gh*, with forces proportional to $k'k''$ and $h'h''$, or to the sections AMDE and *amde*.

*Cor.* 1. This proposition is true when the law of attraction is expressed by any function of the distance. The demonstration is the same as in the corollary of (13).

*Cor.* 2. If the two ellipsoids be so placed, that their centres, and the planes of their principal sections, shall coincide, the surface of the one will be entirely within the other. Also the point which one ellipsoid attracts, will be in the surface of the other, as is plain from the expressions of the coordinate. And hence, the attraction of one ellipsoid upon a point without the surface, is made to depend upon the attraction of another ellipsoid upon a point within the surface.

*Cor.* 3. When the ellipsoids become spheroids of revolution, the two principal sections through the axis of revolution become equal, and will be represented by any two sections whatever passing through the axis at right angles to one another. But, in this case, the attractions of the spheroids on the points may be reduced to two, one acting perpendicular to the axis, and one parallel to it: And it is plain, that these attractions will be to one another as the areas of the sections, perpendicular to their directions.

27. *To find the attraction of an oblate spheroid upon a particle placed without the surface.*

Let $k'$ be the radius of the equator, and $k$ the axis of revolution: and let $a$ be the perpendicular distance of the point without the spheroid from the plane of the equator, and $b$ its distance from the axis. In the first place, it is necessary to determine the semiaxis of another oblate spheroid that shall contain the given point in its surface, and such, that it shall have the same centre, and its equator in the same plane, as the given spheroid; and likewise, the difference of the squares of its semiaxes equal to the difference of the squares of the semiaxes of the given spheroid. Let $h'$ denote the radius of the equator, and $h$ the semiaxis of the required spheroid: then, because the attracted point is to be in the surface of the solid, we have $\frac{a^2}{h^2}+\frac{b^2}{h'^2}=1$ : and, because $h'^2-h^2=k'^2-k^2=\varepsilon^2$; we get

$$\frac{a^2}{h^2}+\frac{b^2}{h^2+\varepsilon^2}=1:$$

Whence,

$$2h^2=a^2+b^2-\varepsilon^2+\sqrt{(a^2+b^2-\varepsilon^2)^2+4a^2\varepsilon^2}:$$

and when $h$ is determined, then $h'=\sqrt{h^2+\varepsilon^2}$.



In consequence of the equation $\frac{a^2}{h^2}+\frac{b^2}{h'^2}=1$, we may suppose, $a=h\ \text{sin.}\ m$, and $b=h'\ \text{cos.}\ m$; let $a'=k\ \text{sin.}\ m$, and $b'=k'\ \text{cos.}\ m$; or $a'=\frac{k}{h}a$, and $b'=\frac{k'}{h'}\times b$: then the point determined by the coordinates $a'$ and $b'$ will be in the surface of the given spheroid, and, consequently, it will be within the surface of the other spheroid. Let M′ denote the mass of the spheroid of which the axis is $h$; and let $e'^2=\frac{h'^2-h^2}{h^2}=\frac{k'^2-k^2}{h^2}$: then (25.) the attractions of this spheroid upon the point within its surface, determined by the coordinates $a$ and $b$, are these, viz.

That perpendicular to the equator, equal to

$$a'\times\frac{3M'}{h^3e'^3}\cdot\left\{e'-\text{arc. tan.}\ e'\right\};$$

and that perpendicular to the axis, equal to

$$b'\times\frac{3M'}{2h^3e'^3}\cdot\left\{\text{arc. tan.}\ e'-\frac{e'}{1+e'^2}\right\}.$$

But (26. Cor. 3.) the attractions of the given spheroid, whose semiaxis are $k$ and $k'$ upon the point without its surface determined by the coordinates $a$ and $b$, will be found by multiplying the preceding expressions respectively by $\frac{k'^2}{k^2}$ and $\frac{kk'}{hh'}$. Let M be the mass of the given spheroid; then $\frac{M}{M'}=\frac{k'^2k}{h'^2h}$; consequently $\frac{k'^2}{h'^2}=\frac{M}{M'}\cdot\frac{h}{k}=\frac{M}{M'}\cdot\frac{a}{a'}$; and $\frac{kk'}{hh'}=\frac{M}{M'}\cdot\frac{h'}{k'}=\frac{M}{M'}\cdot\frac{b}{b'}$: Wherefore, the attractions of the given oblate spheroid upon a point, without the surface determined by the coordinates $a$ and $b$, are as follows, viz.

The attraction perpendicular to the equator, equal to

$$a\times\frac{3M}{h^3e'^3}\left\{e'-\text{arc. tan.}\ e'\right\};$$

and that perpendicular to the axis, equal to

$$b\times\frac{3M}{2h^3e'^3}\left\{\text{arc. tan.}\ e'-\frac{e'}{1+e'^2}\right\}.$$

*Cor.* In the very same manner we may determine the attractions of an oblong spheroid of revolution upon a point without the surface.

### ATTRACTIONS OF ELLIPSOIDS.

28. *Let AMBN be one of the principal sections of an ellipsoid, C the centre, AB and MN the axes, D a point in the periphery of the section, and DO perpendicular to MN (Plate XXXI. fig. 18.); the attraction of the ellipsoid upon a particle placed at the pole A, is to the force with which a particle placed at D is attracted in the direction DO, as AC to DO.* Attractions of Ellipsoids.

Attraction.

Draw DFG perpendicular to AB, and through F describe an ellipsoid similar to the given ellipsoid, and similarly situated, and having the same centre. Conceive an indefinitely great number of planes making indefinitely small angles with one another, to be drawn through DG, so as to divide the two ellipsoids into an indefinitely great number of thin solids or slices: Then, the sections of the ellipsoids made by every one of the planes will be similar and concentric ellipses, each of them having an axis perpendicular to DG (5.). Wherefore the attractions of the elements of the ellipsoid FHKL upon a particle at F, are respectively equal to the attractions of the elements of the ellipsoid AMBN, upon a particle at D in the direction DO (19.). Wherefore, the whole attraction of the ellipsoid FHKL upon a particle at F, is equal to the attraction of the ellipsoid AMBN upon a particle at D, in the direction DO. But the attractions of the ellipsoids AMBN, and FHKL upon particles at A and F, are to one another as AC to CF (8.). Wherefore, the attraction of the ellipsoid AMBN upon a particle at the pole A, is to the force with which it attracts a particle at D in the direction DO, as AC to DO.

29. *The attractions of ellipsoids upon particles placed in the surface, urging them in directions perpendicular to any of the principal sections, are proportional to the distances of the particles from that section.*

Let AMBN be one of the principal sections of an ellipsoid, C the centre, AB and MN the axes of the section, and P a point in the surface of the solid; the attraction of the ellipsoid upon a particle at the pole A (Plate XXXI. fig. 19.), is to the force with which a particle at P is attracted in a direction parallel to AB, as the semiaxis AC is to the distance of P from the principal section perpendicular to AC.

Draw PDQ perpendicular to the section AMBN, and let it meet the surface again in Q; through D describe an ellipsoid similar to AMBN, similarly situated, and having the same centre; and through P draw a section SPRQ perpendicular to AB. As before, divide the solids into an indefinitely great number of thin slices by planes drawn through PQ: the sections made by every one of those planes will be similar, and concentric ellipses having an axis of each perpendicular to PQ (5.). Wherefore, the attractions of the elements of the ellipsoid AMBN, upon a particle at P, in a direction perpendicular to the plane PRQS, are respectively equal to the attractions of the elements of the ellipsoid FHKL, upon a particle at D, in a direction perpendicular to the same plane (19.). Wherefore, the attraction of the ellipsoid AMBN, upon a particle at P, in a direction parallel to the axis AB, is equal to the attraction of the ellipsoid FHKL, upon a particle at D in the same direction. But the ellipsoids AMBN and FHKL being similar, their attractions upon particles at A and F, are to one another as AC to CF (8.); and the attraction of the ellipsoid FHKL, upon a particle at the pole F, is to its attraction upon a particle at D, in a direction parallel to AC, as FC to CN (28.). Wherefore (*ex æquali*), the attraction of the ellipsoid AMBN, upon a particle, at the pole A, is to the force with which it attracts a particle at P, in the direction AC, as AC to CN.

This proposition will enable us to find the attractions of an ellipsoid on all points on the surface, or within the solid, when the attractions at the poles are determined.

30. *To investigate the differential expressions of the attractions at the poles of an ellipsoid.*

Let APD be an ellipsoid; C the centre; AC, CE, and PC, the semiaxes; and PMB a section made by a plane through PC and any point, M in the surface: draw PM (fig. 20.) P$m$ indefinitely near PM, and M$m$ perpendicular to P$m$: also MR perpendicular to the plane ADB, MS perpendicular to PC, and RH perpendicular to AD. Conceive the plane PCB to revolve about PC, so as to describe an indefinitely small angle BCO; and let PM $= f$; the angle KPM, which PM makes with a perpendicular to the axis, $= \theta$; and the angle DCB $= \varphi$: then by proceeding as in (23), it will be found that the attraction of the small pyramid described by the triangle MP$m$, urging a particle at P to the centre of the ellipsoid, is $= d\varphi \,.d\theta \cos.\theta \sin.\theta.f$.

Again, let MR $= x$, HR $= y$, CH $= z$; also let PC $= k$, AC $= k'$, CE $= k''$; then $x = k - f \sin.\theta$; $y = f \cos.\theta \sin.\varphi$; $z = f \cos.\theta \cos.\varphi$: and if we substitute these values in the equation of the ellipsoid (1.), we shall get

$$\frac{(k-f\sin.\theta)^2}{k^2}+\frac{f^2\cos.^2\theta\sin.^2\varphi}{k'^2}+\frac{f^2\cos.^2\theta\cos.^2\varphi}{k''^2}=1: \text{ whence}$$

$$f=\frac{k}{k^2}\cdot\frac{2\sin.\theta}{\frac{\sin.^2\theta}{k^2}+\frac{\cos.^2\theta\sin.^2\varphi}{k'^2}+\frac{\cos.^2\theta\cos.^2\varphi}{k''^2}}$$

This is the value of $f$ at the pole of $k$; and, by a like procedure, its values at the poles of $k'$ and $k''$ may be found, viz.

$$f=\frac{k'}{k'^2}\cdot\frac{2\sin.\theta}{\frac{\sin.^2\theta}{k'^2}+\frac{\cos.^2\theta\sin.^2\varphi}{k^2}+\frac{\cos.^2\theta\cos.^2\varphi}{k''^2}};$$

$$f=\frac{k''}{k''^2}\cdot\frac{2\sin.\theta}{\frac{\sin.^2\theta}{k''^2}+\frac{\cos.^2\theta\sin.^2\varphi}{k^2}+\frac{\cos.^2\theta\cos.^2\varphi}{k'^2}}.$$

Suppose that $k$ is the least of the semiaxes; and let $k'^2=\frac{k^2}{m}$, and $k''^2=\frac{k^2}{n}$: then the values of $f$ at the poles of $k, k', k''$, will be, respectively,

$$f=\frac{2\,k\sin.\theta}{\sin.^2\theta+m\cos.^2\theta\sin.^2\varphi+n\cos.^2\theta\cos.^2\varphi}$$

$$f=\frac{2\,k'\sin.\theta\times m}{m\sin.^2\theta+\cos.^2\theta\sin.^2\varphi+n\cos.^2\theta\cos.^2\varphi}$$

$$f=\frac{2\,k''\sin.\theta\times n}{n\sin.^2\theta+\cos.^2\theta\sin.^2\varphi+m\cos.^2\theta\cos.^2\varphi}$$

Now, let A, A′, A″, denote the attractions of the spheroid upon particles placed at the poles of $k, k', k''$; then, by substituting the values of $f$ just found in the foregoing differential expression, we get

$$A=k\times\iint\frac{2\,d\varphi\;d\theta.\cos.\theta\sin.^2\theta}{\sin.^2\theta+m\cos.^2\theta\sin.^2\varphi+n\cos.^2\theta\cos.^2\varphi}$$

$$A' = k' \times \iint \frac{m \times 2 d\varphi . d\theta \cos \theta \sin.^2\theta}{m \sin.^2\theta + \cos.^2\theta \sin.^2\varphi + n \cos.^2\theta \cos.^2\varphi}$$

$$A'' = k'' \times \iint \frac{n \times 2 d\varphi . d\theta \cos. \theta \sin.^2\theta}{n \sin.^2\theta + \cos.^2\theta \sin.^2\varphi + m \cos.^2\theta \cos.^2\varphi}$$

the limits of the integrals being from $\theta = o$ and $\varphi = o$ to $\theta = \frac{\pi}{2}$ and $\varphi = 2\pi$.

31. *To reduce the expressions of the polar attractions to the most simple integrals.*

Let us consider the general expression

$$\iint \frac{d\varphi . d\theta \cos. \theta \sin.^2\theta}{\alpha \sin.^2\theta + \beta \cos.^2\theta \sin.^2\varphi + \gamma \cos.^2\theta \cos.^2\varphi}$$

which includes all the formulas found in (30.) Let $p = \alpha \sin.^2\theta + \beta. \cos.^2\theta$; and $q = \alpha \sin.^2\theta + \gamma \cos.^2\theta$; then the above expression will become

$$\iint \frac{d\varphi. d\theta \cos. \theta \sin.^2\theta}{p \sin.^2\varphi + q \cos.^2\varphi}.$$

Suppose $\sqrt{\frac{q}{p}}. \frac{\sin.\varphi}{\cos.\varphi} = \frac{\sin. u}{\cos. u}$: then the preceding expression will become, by substitution,

$$\iint \frac{du . d\theta \cos. \theta \sin.^2\theta}{\sqrt{p.q}};$$

the limits of $u$ being from 0 to $2\pi$; wherefore, by integrating with regard to $u$, and restoring the values of $p$ and $q$, the integral becomes

$$2\pi. \int \frac{d\theta . \cos. \theta \sin.^2\theta}{\sqrt{(\alpha \sin.^2\theta + \beta \cos.^2\theta).(\alpha \sin.^2\theta + \gamma \cos.^2\theta)}}$$

and, by putting $x = \sin. \theta$, the integral, which is to be taken from $\theta = 0$ to $\theta = \frac{\pi}{2}$, or from $x = 0$ to $x = 1$, will become

$$2\pi. \int \frac{x.^2 dx}{\sqrt{\left\{\beta + (\alpha - \beta) x^2\right\} . \left\{\gamma + (\alpha - \gamma) x^2\right\}}}.$$

If now we take $\alpha$, $\beta$, $\gamma$, so as to make the assumed expression coincide with the quantities A, A′ A″, respectively, we shall get

$$A = 4\pi k . \int \frac{x^2 dx}{\sqrt{\left\{m + (1-m)x^2\right\} . \left\{n + (1-n)x^2\right\}}}$$

$$A' = 4\pi k' . \int \frac{m . x^2 dx}{\sqrt{\left\{1 + (m-1)x^2\right\} . \left\{n + (m-n)x^2\right\}}}$$

$$A'' = 4\pi k'' . \int \frac{n . x^2 dx}{\sqrt{\left\{1 + (n-1)x^2\right\} . \left\{m + (n-m)x^2\right\}}}$$

These expressions have the inconvenience of containing different factors in the denominators; but they may be reduced to others having the same factors, by putting $x = \frac{\tau}{\sqrt{m + (1-m)\tau^2}}$ in the second and $x = \frac{\tau}{\sqrt{n + (1-n)\tau^2}}$ in the third; we thus get



$$A = 4\pi k . \int \frac{x^2 dx}{\sqrt{\left\{m + (1-m) x^2\right\} . \left\{n + (1-n) x^2\right\}}}$$

$$A' = 4\pi k' . \int \frac{m . \tau^2 d\tau}{\left\{m + (1-m)\tau^2\right\}^{\frac{3}{2}} . \left\{n + (1-n)\tau^2\right\}^{\frac{1}{2}}}$$

$$A'' = 4\pi k'' . \int \frac{n . \tau^2 d\tau}{\left\{n + (1-n)\tau^2\right\}^{\frac{3}{2}} . \left\{m + (1-m)\tau^2\right\}^{\frac{1}{2}}}$$

Now let

$\frac{1-m}{m} = \frac{k'^2 - k^2}{k^2} = \lambda^2$; and $\frac{1-n}{n} = \frac{k''^2 - k^2}{k^2} = \lambda'^2$:

Also let the mass of the ellipsoid $= M = \frac{4\pi k k' k''}{3} = \frac{4\pi k^3}{3\sqrt{mn}}$; then $\frac{3M}{k^3} = \frac{4\pi}{\sqrt{mn}}$: wherefore, by substitution, we get

$$A = k . \frac{3M}{k^3} . \int \frac{x^2 dx}{\sqrt{(1 + \lambda^2 x^2) . (1 + \lambda'^2 x^2)}}$$

$$A' = k' . \frac{3M}{k^3} . \int \frac{x^2 dx}{\left\{1 + \lambda^2 x^2\right\}^{\frac{3}{2}} . \left\{1 + \lambda'^2 x^2\right\}^{\frac{1}{2}}}$$

$$A'' = k'' \frac{3M}{k^3} . \int \frac{x^2 dx}{\left\{1 + \lambda^2 x^2\right\}^{\frac{1}{2}} . \left\{1 + \lambda'^2 x^2\right\}^{\frac{3}{2}}}$$

the integrations extending from $x = 0$ to $x = 1$.

These integrals cannot be expressed in finite terms. When $\lambda$ and $\lambda'$, or the eccentricities of the ellipsoid are small, the values of the integrals may easily be found to a sufficient degree of exactness, by series.—They may likewise be all expressed by means of this fluent, viz.

$F = \int \frac{dx}{\sqrt{(1 + \lambda^2 x^2) . (1 + \lambda'^2 x^2)}}$ (from $x = o$ to $x = 1$) and its partial fluxions. Thus we have, in general, $\int \frac{x^2 dx}{\sqrt{(1 + \lambda^2 x^2) . (1 + \lambda'^2 x^2)}} =$

$$\frac{x^3}{\sqrt{(1 + \lambda^2 x^2) . (1 + \lambda'^2 x^2)}} + \frac{1}{\lambda} . \left(\frac{dF}{d\lambda}\right) + \frac{1}{\lambda'} . \left(\frac{dF}{d\lambda'}\right)$$

Wherefore, making $x = 1$, we get

$$A = k. \frac{3M}{k^3} . \left\{\frac{1}{\sqrt{(1 + \lambda^2) . (1 + \lambda'^2)}} + \frac{1}{\lambda}\left(\frac{dF}{d\lambda}\right) + \frac{1}{\lambda'} . \left(\frac{dF}{d\lambda'}\right)\right\}$$

$$A' = k' . \frac{3M}{k^3} . \frac{1}{\lambda} . \left(\frac{dF}{d\lambda}\right).$$

$$A'' = k'' . \frac{3M}{k^3} . \frac{1}{\lambda'} . \left(\frac{dF}{d\lambda'}\right).$$

32. *To find the forces with which a homogeneous ellipsoid attracts a particle placed in the surface, or within the solid, in directions perpendicular to the principal sections.*

Let $k$, $k'$, $k''$, denote the semiaxes of an ellipsoid,

Attraction. and $a$, $b$, $c$ (respectively parallel to $k$, $k'$, $k''$), the perpendicular distances of a particle placed in the surface, or within the solid, from the principal sections: then, from what is proved in (29.), the attractions we are seeking will be found by multiplying the polar attractions by $\frac{a}{k}, \frac{b}{k'}, \frac{c}{k''}$. Wherefore the forces that urge the particle in the directions of $a$, $b$, and $c$, are respectively, $a \times \frac{3\,M}{k^3}$.

$$\left\{\frac{1}{\sqrt{(1+\lambda^2).(1+\lambda'^2)}}+\frac{1}{\lambda}.\left(\frac{dF}{d\lambda}\right)+\left(\frac{dF}{d\lambda'}\right)\right\};$$

$$b \times \frac{3\,M}{k^3}.\frac{1}{\lambda}.\left(\frac{dF}{d\lambda}\right);$$

$$c \times \frac{3\,M}{k^3}.\frac{1}{\lambda'}.\left(\frac{dF}{d\lambda'}\right):$$

Which formulas serve both for points in the surface, and within the solid, for the reason already explained in (25.).

33. *To find the attractions of an ellipsoid upon a particle placed without the surface.*

Let $k$, $k'$, $k''$ be the semiaxis of the ellipsoid, and $a$, $b$, $c$ (respectively parallel to $k$, $k'$, $k''$), the coordinates of a particle without the surface Let $h$, $h'$, $h''$, so related to $k$, $k'$, $k''$, that $h'^2 - h^2 = k'^2 - k^2$ and $h''^2 - h^2 = k''^2 - k^2$, denote the semiaxis of another ellipsoid, which contains the attracted point in its surface, and has its principal sections in the same planes as the given ellipsoid: then, because the attracted point is in the surface, we have (1.)

$$\frac{a^2}{h^2}+\frac{b^2}{h'^2}+\frac{c^2}{h''^2}=1:$$

And, because $h'^2 - h^2 = k'^2 - k^2 = \varepsilon^2$, and $h''^2 - h^2 = k''^2 - k^2 = \varepsilon'^2$, we get

$$\frac{a^2}{h^2}+\frac{b^2}{h^2+\varepsilon^2}+\frac{c^2}{h^2+\varepsilon'^2}=1.$$

This equation now contains only one unknown quantity; and it is plain, that one value of $h$, and only one, can be found from it. For, when $h = 0$, the function on the left hand side is infinitely great: And while $h$ increases from 0 *ad infinitum*, the same function decreases continually from being infinitely great, to be infinitely little. When $h$ is found, then $h' = \sqrt{h^2+\varepsilon^2}$, and $h'' = \sqrt{h^2+\varepsilon'^2}$. Because $a$, $b$, $c$, are the coordinates of a point in the surface of the ellipsoid, we may suppose $a = h$ sin. $m$, $b = h'$ cos. $m$ sin. $n$, $c = h''$ cos. $m$ cos. $n$: let $a' = k$ sin. $m$, $b' = k'$ cos. $m$ sin. $n$, $c' = k''$ cos. $m$ cos. $n$; or $a' = \frac{k}{h} \times a$, $b' = \frac{k'}{h'} \times b$, $c' = \frac{k''}{h''} \times c$; then $a'$, $b'$, $c'$, will be the coordinates of a point in the surface of the given ellipsoid, and consequently, it will be within the other solid. Let $M'$ denote the mass of the ellipsoid of which $h$, $h'$, $h''$ are the semiaxes; also let $\lambda^2 = \frac{h'^2-h^2}{h^2} = \frac{k'^2-k^2}{k^2}$; and $\lambda'^2 = \frac{h''^2-h^2}{h^2} = \frac{k''^2-k^2}{k^2}$; Attraction.

then, F denoting the same fluent as before, the attractions of this ellipsoid upon the point within it, determined by the coordinates $a'$, $b'$, $c'$, in the directions of those coordinates, are (32.) respectively equal to

$$a' \times \frac{3\,M'}{h^3}\left\{\frac{1}{\sqrt{(1+\lambda^2)(1+\lambda'^2)}}+\frac{1}{\lambda}.\left(\frac{dF}{d\lambda}\right)+\frac{1}{\lambda}.\left(\frac{dF}{d\lambda'}\right)\right\},$$

$$b' \times \frac{3\,M'}{h^3} \times \frac{1}{\lambda}.\left(\frac{dF}{d\lambda}\right),$$

$$c' + \frac{3\,M'}{h^3} \times \frac{1}{\lambda'}.\left(\frac{dF}{d\lambda'}\right).$$

Now, the attractions of the given ellipsoid upon the point without the surface, determined by the coordinates $a$, $b$, $c$, will be found (26.) by multiplying the preceding expressions respectively by $\frac{k'\,k''}{h'\,h''}$, $\frac{k\,k''}{h\,h''}$, $\frac{k\,k'}{h\,h'}$. Let M be the mass of the given ellipsoid; then $\frac{M}{M'} = \frac{k\,k'\,k''}{h\,h'\,h''}$; consequently $\frac{k'\,k''}{h'\,h''} = \frac{M}{M'}.\frac{h}{k} = \frac{M}{M'}.\frac{a}{a'}$; and $\frac{k\,k''}{h\,h''} = \frac{M}{M'} \times \frac{b}{b'}$; and $\frac{k\,k'}{h\,h'} = \frac{M}{M'} \times \frac{c}{c'}$: wherefore, the attractions of the given ellipsoid upon the point without the surface, determined by $a$, $b$, $c$, in the directions of those coordinates, are respectively equal to $a \times \frac{3\,M}{h^3} \times$

$$\left\{\frac{1}{\sqrt{(1+\lambda^2)(1+\lambda'^2)}}+\frac{1}{\lambda}\left(\frac{dF}{d\lambda}\right)+\frac{1}{\lambda'}.\left(\frac{dF}{d\lambda'}\right)\right\},$$

$$b \times \frac{3\,M}{h^3} \times \frac{1}{\lambda}.\left(\frac{dF}{d\lambda}\right)$$

$$c \times \frac{3\,M}{h^3} \times \frac{1}{\lambda'}\left(\frac{dF}{d\lambda'}\right).$$

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The preceding propositions contain a complete theory of homogeneous elliptical spheroids. They enable us to compute the attractive force with which a solid of this kind urges a particle placed anywhere in the surface, or within the solid, or without it. It remains, indeed, to find the exact value of the function F in its general form, to which we can do no more than approximate by series; but this is an analytical difficulty, which it is impossible to overcome; because the nature of this function is such, that it cannot be expressed in finite terms by the received notation of analysis.

In the preceding investigations, we have followed the method of Maclaurin for points situated in the surface of a spheroid, or within the solid. This method has always been justly admired; but neither its inventor, nor, as far as we know, any other Geometer, has applied it, excepting to spheroids of revolution; and it is here, for the first time, extended to ellipsoids. In regard to points without the surface, we have employed the method first given by Mr Ivory, in the *Philosophical Transactions* for 1809. The combination of these two methods has enabled us to derive the attractions of an ellipsoid on a point placed anywhere, from the attractions at the poles. Thus, this extremely complicated problem has, by geometrical reasoning of no great difficulty, been reduced to the investigation of the polar attractions, which are the only cases that require a direct computation.

34. *Of the attractions of spheroids composed of elliptical shells that vary in their densities and figures according to any law.*

When a spheroid is composed of concentric elliptical shells of variable density and figure, we may consider every shell as the difference of two homogeneous spheroids of the same density with the shells, and having their surfaces coinciding with the surfaces of the shell. The attractions of the spheroids being computed by the preceding methods, their difference will be equal to the attractions of the shell; and the integral obtained by summing the attractions of all the shells, will give the attractions of the heterogeneous spheroid. This case, therefore, gives rise to no new difficulties, except what are purely mathematical, and depend upon the law, according to which, the densities and figures of the shells are supposed to vary. (CC.)

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ATTRACTION OF MOUNTAINS. See Mountains, Attraction of, in the *Encyclopædia*, and in this Supplement.

ATWOOD (George), an Author celebrated for the accuracy of his mathematical and mechanical investigations, and considered as particularly happy in the clearness of his explanations, and the elegance of his experimental illustrations, was born in the early part of the year 1746. He was educated at Westminster school, where he was admitted in 1759. Six years afterwards he was elected *off* to Trinity College, Cambridge. He took his degree of Bachelor of Arts in 1769, with the rank of third *wrangler*, Dr Parkinson, of Christ's College, being senior of the year. This distinction was amply sufficient to give him a claim to further advancement in his own College, on the list of which he stood foremost of his contemporaries; and, in due time, he obtained a fellowship, and was afterwards one of the tutors of the College. He became Master of Arts in 1772; and, in 1776, was elected a Fellow of the Royal Society of London.

The higher branches of the Mathematics had, at this period, been making some important advances at Cambridge, under the auspices of Dr Waring, and many of the younger members of the University became diligent labourers in this extensive field. Mr Atwood chose, for his peculiar department, the illustration of mechanical and experimental philosophy, by elementary investigations and ocular demonstrations of their fundamental truths. He delivered, for several successive years, a course of lectures in the Observatory of Trinity College, which were very generally attended, and greatly admired. In the year 1784, some circumstances occurred which made it desirable for him to discontinue his residence at Cambridge; and soon afterwards Mr Pitt, who had become acquainted with his merits by attending his lectures, bestowed on him a patent office, which required but little of his attendance, in order to have a claim on the employment of his mathematical abilities in a variety of financial calculations, to which he continued to devote a considerable portion of his time and attention throughout the remainder of his life.*

The following, we believe, is a correct list of Mr Atwood's publications:

1. *A Description of Experiments to illustrate a Course of Lectures.* 8vo. About 1775, or 1776.

2. This work was reprinted with additions, under the title of *An Analysis of a Course of Lectures on the Principles of Natural Philosophy.* 8vo. Cambr. 1784.

3. *A General Theory for the Mensuration of the Angle subtended by two objects, of which one is observed by Rays after two Reflections from plane Surfaces, and the other by Rays coming directly to the Spectator's Eye.* Phil. Trans. 1781, p. 395.

4. *A Treatise on the Rectilinear Motion and Rotation of Bodies, with a Description of Original Experiments relative to the Subject.* 8vo. Cambr. 1784.

5. *Investigations founded on the Theory of Motion, for determining the Times of Vibration of Watch Balances.* Phil. Trans. 1794, p. 119.

6. *The Construction and Analysis of Geometrical Propositions, determining the positions assumed by homogeneal bodies, which float freely, and at rest, on a fluid's surface; also Determining the Stability of Ships, and of other Floating Bodies.* Phil. Trans. 1796, p. 46.

7. *A Disquisition on the Stability of Ships.* Phil. Trans. 1798, p. 201.

8. *A Review of the Statutes and Ordinances of Assize, which have been established in England from the 4th year of King John, 1202, to the 37th of his present Majesty.* 4to. Lond. 1801.

9. *A Dissertation on the Construction and Properties of Arches.* 4to, Lond. 1801.

10. *A Supplement to a Tract entitled a Treatise on the Construction and Properties of Arches, published*

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* See *Literary Memoirs of Living Authors*, 2 vol. 8vo, Lond. 1798; *Morning Herald*, 17th July 1807; *Nichols's Literary Anecdotes of the Eighteenth Century*, Vol. VIII. 8vo, Lond. 1814.

*Fig. 1.*

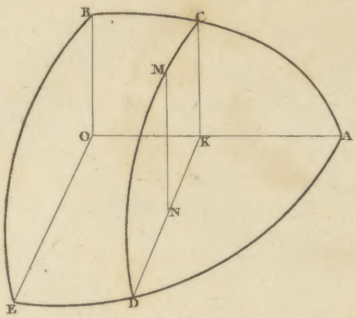
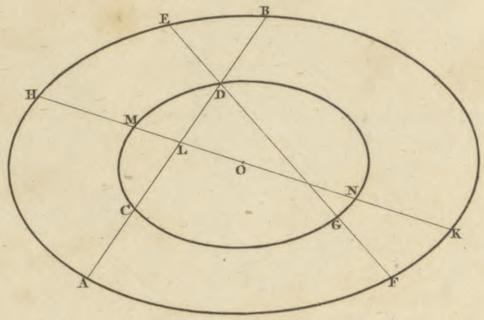



*Fig. 2.*



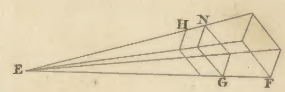




*Fig. 4.*

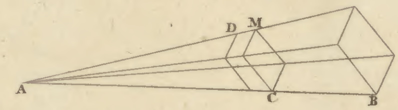



*Fig. 3.*

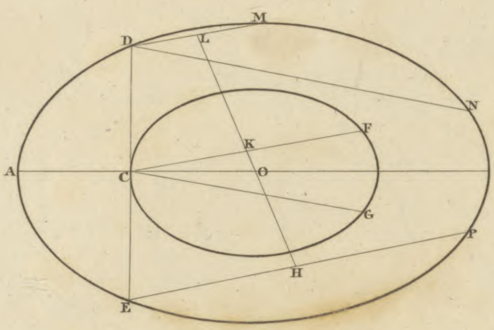



*Fig. 5.*

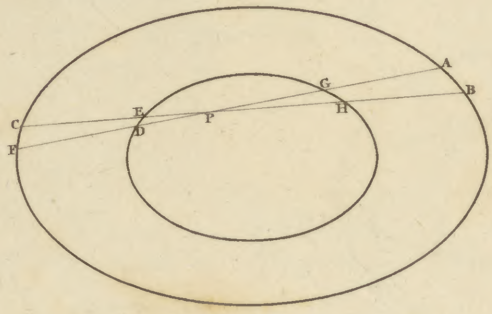



*Fig. 6.*

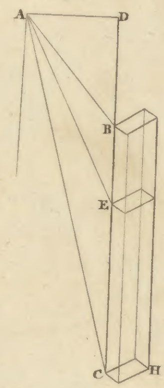



*Fig. 7.*

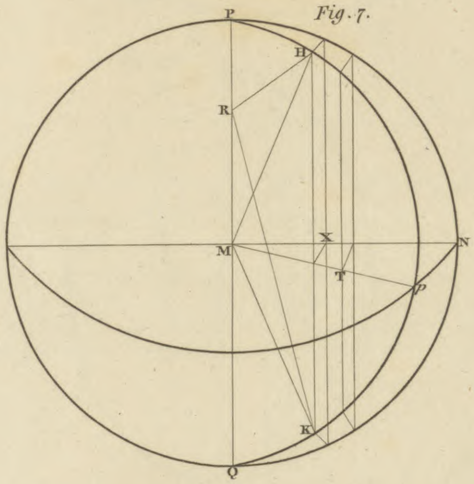



*Fig. 7.*

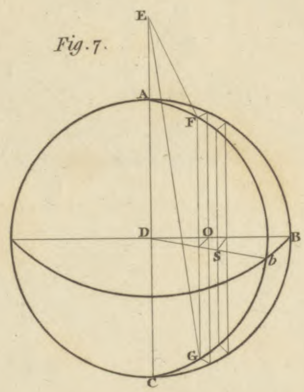



*Fig. 8.*

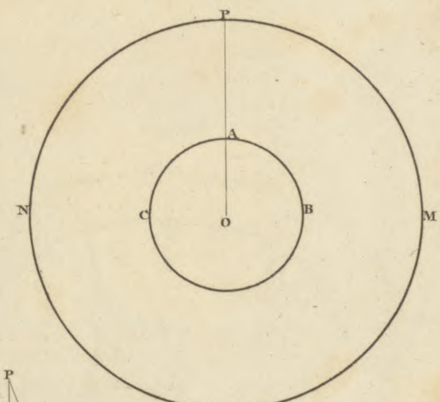



*Fig. 9.*

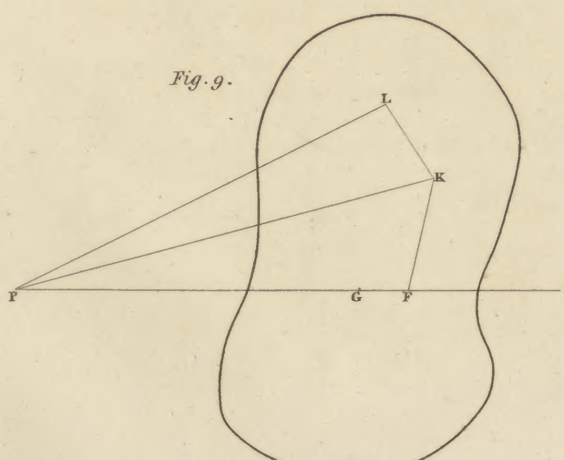
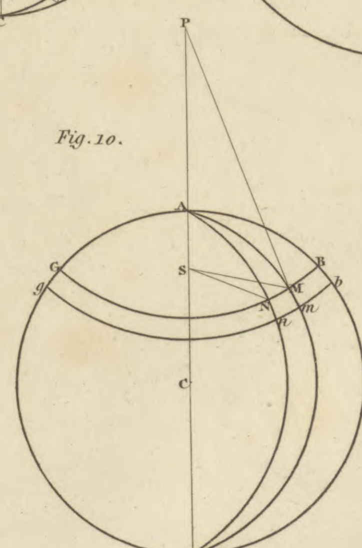



*Fig. 10.*




Published by A. Constable & Co. 1816.

W. Archibald sculp.

Fig. 11.

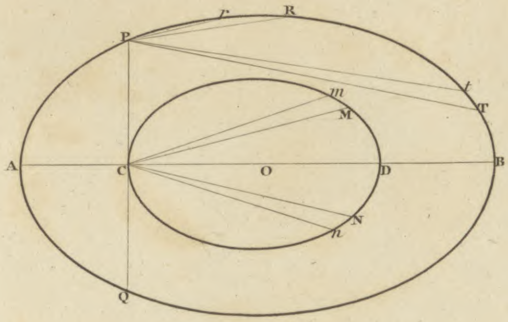



Fig. 12.

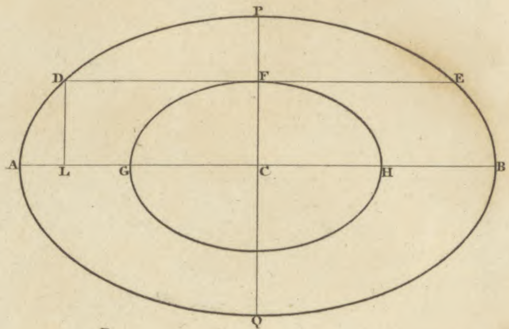



Fig. 14.

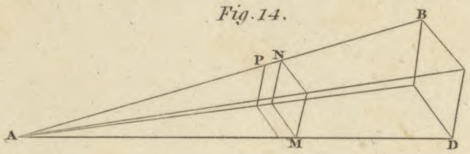



Fig. 13.

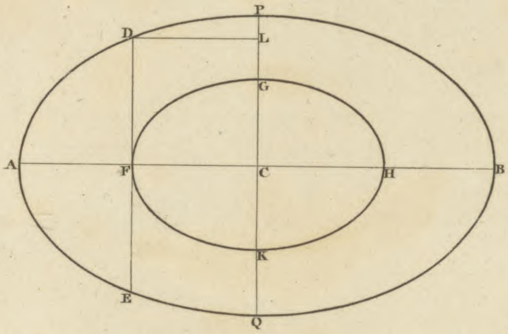



Fig. 15.

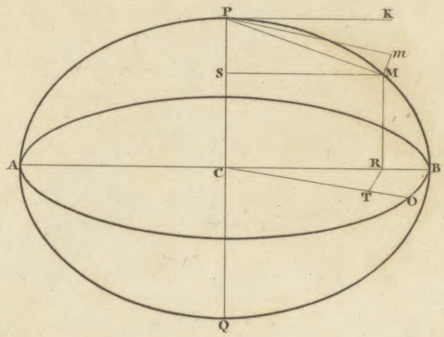



Fig. 16.

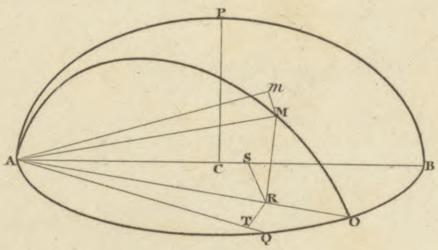



Fig. 17.

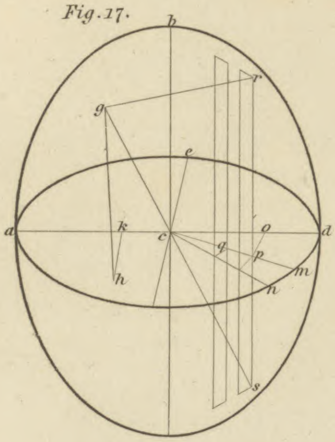



Fig. 19.

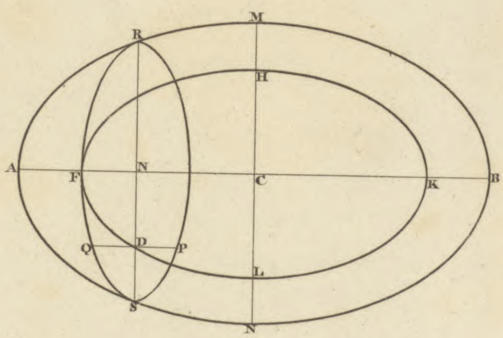



Fig. 18.

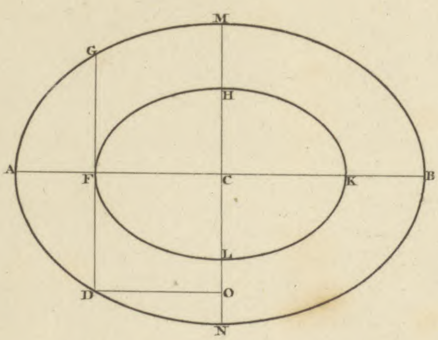



Fig. 17.

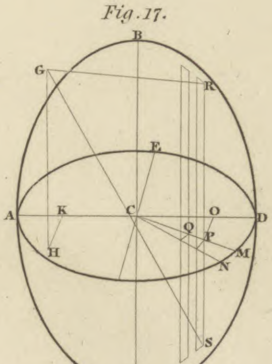
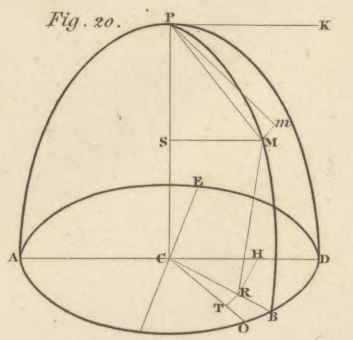



Fig. 20.



Atwood.

*in the year* 1801 ; *and containing Propositions for Determining the weights of the several sections which constitute an arch, inferred from the angles. Also containing a Demonstration of the angles of the several sections, when they are inferred from the weights thereof. To which is added, a Description of original experiments to verify and illustrate the principles in this treatise. With occasional remarks on the construction of an iron bridge of one arch, proposed to be erected over the river Thames at London. Part II. By the author of the first part.* 4to, Lond. 1804. Dated 24th Nov. 1803.

11. A *Treatise on Optics* is mentioned by Nichols as having been partly printed by Bowyer in 1776, but never completed.

It may be very truly asserted, that several of these works of Mr Atwood have materially contributed to the progress of science, by multiplying the modes of illustration, which experimental exhibitions afford for the assistance of the instructor; at the same time, they can scarcely be said to have extended very considerably the bounds of human knowledge, or to demonstrate that their author was possessed of any extraordinary talent or energy of mind in overcoming great difficulties, or in inventing new methods of reasoning. The *Analysis of a Course of Lectures* has been little read: and it bears evident marks of having been composed before Mr Atwood had acquired a habit of accurate reasoning on Physical subjects. In the first page, for example, the forces of cohesion and gravitation are completely confounded; and in the third we find the idea of perfect spheres touching each other in a greater or less number of points, notwithstanding the appearance of precision which the author attempts to maintain in his language.

The object of the paper on *Reflection* is, to illustrate and improve the construction of Hadley's quadrant; and Mr Atwood proposes, for some particular purposes in practical Astronomy, two new arrangements of the speculums, by which the rays are caused to move in different planes, and which he considers as affording greater accuracy for the measurement of small angles than the common form of the instrument, although not of general utility, nor very easily adjusted for observation.

The treatise on *Rectilinear motion and rotation* exhibits a good compendium of the elementary doctrines of mathematical Mechanics; but it shows a great deficiency in the knowledge of the higher refinements which had been introduced into that science by Daniel Bernoulli, and Euler, and Lagrange. The properties of simply accelerated and retarded motion are first discussed, and the phenomena of penetration experimentally examined; the laws of varying forces are then investigated, and the properties of the pendulum demonstrated; the vibrations of an elastic chord are calculated, "considering the whole mass to be concentrated in the middle point," as an approximation; and then, instead of imitating and simplifying the elegant but complicated demonstrations of the continental mathematicians, the author most erroneously repeats, in the words of Dr Smith, the exploded doctrine, that "the string, during any instant of its vibration, will coincide with the harmonic curve." The subject of a resistance, varying as the square of the velocity, is next examined; and some useful experiments on the descent of bodies in water are stated in confirmation of the theory. On this occasion, the author observes, with regard to the formation of the different strata of the earth, that bodies disposed to break into large masses, though specifically lighter, may easily have descended more rapidly through a fluid, than denser but more brittle bodies, so that the natural order of densities may thus have become inverted. He next examines the theory of rotation, and relates some very interesting experiments on rectilinear and rotatory motions; and he shows that Emerson and Desaguliers were totally mistaken in asserting "that the momentum produced is always equal to the momentum which produces it." The last section of the work, which is devoted to the subject of free rotation, is the most elaborate of the whole; but it exhibits no material extension of the earlier investigations of the Bernoullis and Professor Vince; nor does it contain the important proposition of Segner, relating to the existence of three axes of permanent rotation, at right angles to each other, in every body, however irregular.

Notwithstanding these partial objections, the work may still, in many respects, be considered as classical. The paper on *Watch-balances* is principally intended to show the advantages which may be obtained, in Mr Mudge's construction, from the effect of subsidiary springs in rendering the vibrations isochronous, their actions being limited to certain portions of the arc of motion. If the author has here again omitted to follow the Continental Mathematicians in some of their refinements of calculation, it must be confessed that his view of the subject has, in this instance, not only the advantage of simplicity, but also that of a nearer approach to the true practical state of the question, than is to be found in the more complicated determinations which had been the result of the labours of some of his predecessors.

But, whatever may be the merits of these investigations, they appear to be far exceeded in importance by the papers on *Ships*, the first of which obtained for its author the honour of a Copleian Medal. Its principal object is to show how much the stability of a ship will commonly vary, when her situation, with respect to the horizon, is materially altered; and how far the assumptions of theoretical writers, respecting many others of the forces concerned in Naval Architecture, will generally differ from the true state of these forces when they actually occur in Seamanship. In the second part of the investigation, some errors of Bouguer and of Clairbois are pointed out, and the theoretical principles of stability are exemplified by a detailed calculation, adapted to the form and dimensions of a particular vessel, built for the service of the East India Company.

The latter years of our author's life do not appear to have been productive of any material advantage to Science. His application to his accustomed pursuits was unremitting; but his health was gradually declining. He had no amusement, except such as was afforded by the continued exercise of his mind, with

a change of the object only; the laborious game of chess occupying, under the name of a recreation, the hours which he could spare from more productive exertions. He became paralytic some time before his death; and though he partially recovered his health, he did not live to complete his 62d year.

His researches concerning the history of the *Assize of Bread* must have required the employment of considerable diligence, and some judgment, in the discovery and selection of materials; although certainly the subject was not chosen for the purpose of affording a display of talent. His opinion respecting the operation of the assize, as favourable to the community, may by some be thought to be justified by the want of success which has hitherto attended the experiment on its suspension; but the advocates of that measure would certainly not admit the trial of a year to be sufficient for appreciating its utility.

The title-pages of the works on *Arches* explain the occasion on which they were brought forwards, and at the same time exhibit a specimen of the want of order and precision which seems to have begun to prevail in the author's faculties: and the works themselves betray a neglect of the fundamental principles of Mechanics, which is inconceivable in a person who had once reasoned with considerable accuracy on mathematical subjects. An anonymous Critic, who is supposed to have been the late Professor Robison (*British Critic*, Vol. XXI. Jan. 1804), very decidedly, and, at the same time, very respectfully asserted Mr Atwood's error in maintaining, that there was no manner of necessity for the condition, that the general curve of equilibrium of an arch should pass through some part of every one of the joints by which it is divided: and in fact we may very easily be convinced of the truth of this principle, if we reflect that the curve of equilibrium is the true representative of the direction of all the forces acting upon each of the blocks; and that if the whole pressure be anywhere directed to a point situated beyond the limit of the joint, there can be nothing whatever to prevent the rotation of the block on the end of the joint as a centre, until some new position of the block shall have altered the direction of the forces, or until the whole fabric be destroyed. The Critic has also very truly remarked, that the effects of friction have never been sufficiently considered in such arrangements: but a later Author has removed a considerable part of this difficulty in an anonymous publication, by showing, that no other condition is required for determining these effects, than that every joint should be perpendicular to the direction of the curve of equilibrium, either accurately, or within the limit of a certain angle, which is constant for every substance of the same kind, and which he has termed the angle of repose.

In the appointment which enabled Mr Atwood to devote a considerable part of his life to scientific researches, he appears to have had no successor. It was held, and perhaps wisely, that such sinecures have regularly become, in process of time, mere instruments of party interest, instead of being bestowed as encouragements to merit; and it seems to be the invariable maxim of the British Government, that talents deserve no protection, unless they are immediately employed in the service of the Church or of the State; that ornamental accomplishments repay their possessor by the splendour which they confer on his personal existence, but that, in a commercial country, the actual utility of mental as well as of corporal powers, must be measured by their effects; and that these effects must be of a negociable kind, in order to have a claim to reward. Other Nations, and other Sovereigns, have often thought and acted differently; and they have, perhaps, obtained a forced growth of Science or of Literature, which has contributed, in some degree, to the embellishment of their age; but where the native forest tree acquires so often a form at once beautiful and magnificent, though exposed to all the storms of the seasons, there is little reason to lament the want of the shelter of the Plantation, or of the artificial warmth of the Conservatory. (FO.)

# ADDENDUM.

ANNUITIES. As an addition to the article ANNUITIES, we beg to insert here an expeditious method of calculating the values of annuities on single or joint lives, from any tables or bills of mortality, with sufficient accuracy for all practical purposes.

We must begin by determining the mean complement of life, according to the average number of deaths during a certain period, which must vary according to the nature of the proposed calculation; being shorter as the rate of interest is higher; and as the number of lives concerned is greater; but not requiring to be very accurately defined. If the rate of interest be $r$, we must find the time in which the number of deaths is expressed by the fraction $\frac{3}{r+3}$ of the whole number of survivors at the given age, for a single life: for two lives, the fraction must be $\frac{3}{r+5}$, and for three, $\frac{3}{r+7}$; and, in each of these cases, the time determined from the age of the oldest life must be employed for finding the complements of both the others.

Having thus calculated the complements for each of the ages, we may, in most instances, save ourselves the trouble of further computation, by employing tables of the value of annuities on one and two lives, according to Demoivre's hypothesis. For this purpose, we have only to subtract the complement from 86, and we obtain an equivalent life on this hypothesis. If we take, for example, the age of 20, the number of survivors in the Northampton tables is 5132; and, for a single life, at 3 and at 6 per cent. we must find the time at which they are reduced $\frac{3}{6}$ and $\frac{3}{9}$ respectively; that is, to about 2566 and 3421: now at 54 and 43, the numbers are 2530 and 3404; and $\frac{5132 \times 34}{5132-2530} = 67{\cdot}07$, and $\frac{5132 \times 23}{5132-3404} = 68{\cdot}3$; whence the equivalent ages in Demoivre's tables are 18·93 and 17·7, giving 18·62 and 12·43, for the value of the annuity; while Dr Price's table, deduced from the actual decrements at all ages, gives 18·64 and 12·40.

The utility of this mode of calculation will be still further illustrated by a comparison of the very different values of lives, as indicated by different tables. Taking, for example, the age of 30, and the interest at 5 per cent. we may find the value of the annuity, by this approximation, in different situations, for which correct tables have been published by Dr Price, and may thence infer how much nearer it approaches to the truth than the generality of the results approach to each other:

| | | | |
|---|---|---|---|
| London, 1730 | Compl. 41·52 | Value 11·22 | Dr P. 11·6 |
| Northampton | 57·05 | 13·09 | 13·07 |
| Sweden, males | 67·93 | 14·04 | 13·89 |
| Deparcieux | 71·11 | 14·28 | 14·72 |
| Sweden, females | 75·60 | 14·58 | 14·27 |

According to the bills of mortality of London for 1815, out of 9472 survivors at 30, 5573 lived to 50, and this is near enough to $\frac{3}{8}$ for our purpose: hence the complement is 48·58, and the value of an annuity at 5 *per cent.* 12·16 years' purchase. Where the age is much greater, the approximation is somewhat less accurate, though not often materially erroneous; thus, at 70, the values, according to the Northampton tables, at 3 and 6 per cent. are 6·23 and 5·35, instead of 6.73 and 5.72 respectively.

In the values of joint lives, there is more difference, according to the different tables employed, than in those of single lives: thus, at 30, the value of an annuity, at 4 per cent. on a single life, differs at Northampton, and in Sweden, in the proportion of 14·78 to 16·00, or of 12 to 13; but, for two joint lives at 30, in that of 11·31 to 12·96, or of 7 to 8; and for three lives, the disproportion would be still greater.

In the absence of Demoivre's tables, or for cases to which they do not extend, it becomes necessary to calculate the value of the annuity for each particular instance. Calling then the complement, as already determined, $a$, the number of survivors after $x$ years will be represented by $a-x$, and the present value of any sum to be paid to each of them by $av^x - xv^x$, $v$ being the present value of a unit payable at the end of a year: and if we suppose such payments to be made continually, their whole present value may be found by multiplying this expression by the fluxion of $x$, and finding the fluent, which will be $-pv^x(a-x-p)$, $p$ being $= -\frac{1}{\text{HL}v}$, or the reciprocal of the hyperbolical logarithm of the amount of a unit after a year. When $x$ vanishes, this fluent becomes $-p(a-p)$, and when $x=a$, $p^2v^a$; the difference, divided by $a$, gives the present value of the annuity, $p - \frac{p^2}{a} + \frac{p^2v^a}{a}$; from which, when the annuity is supposed to become due and to be paid periodically, we must subtract in all cases half a payment; that is, $\frac{1}{2}$ for yearly payments, and $\frac{1}{4}$ for quarterly; and if, at the same time, we choose to assume that money is capable of being improved by laying out the interest more frequently than once

a year at the given rate, we must alter the value of $v$ accordingly.

For two joint lives, the complement of the elder, determined from the fraction $\frac{3}{r+5}$, being $a$, and that of the younger, deduced from the deaths in an equal number of years, $b$, we have for the binary combinations of the survivors, after $x$ years, $(a-x)(b-x)$, and the fluent will be $-pv^x\ (ab-(a+b)(x+p)+x^2+2px+2p^2)$, which, corrected and divided by $ab$, gives the value of the annuity $p-\frac{p^2}{ab}(a+b-2p)-\frac{p^2v^a}{ab}(a-b+2p)$; and this, with the deduction of half a payment, agrees with the tables calculated on Demoivre's hypothesis, taking the same complements of life.

But for three lives we have no such tables, and this method of calculation becomes therefore of still greater importance. Employing here the fraction $\frac{3}{r+7}$ for the oldest life, we must determine the complement $a$ for this life, and those of the two younger, $b$ and $c$, from an equal period. The combinations will then be $(a-x)(b-x)(c-x)=abc-(ab+ac+bc)x+(a+b+c)x^2-x^3$, which we may call $d-ex+fx^2-x^3$; hence the fluent is found $-pv^x\Big(d-e(x+p)+f(x^2+2px+2p^2)-(x^3+3px^2+6p^2x+6p^3)\Big)$ this, when $x$ vanishes, becomes $-p\ (d-ep+f\,p^2-6p^3)$, and calling this $-pg$, the corrected fluent will give the value of the annuity $\frac{pg}{d}-\frac{pv^a}{d}\ (g-ea+fa^2+2fpa-a^3-3pa^2-6p^2a)$. Thus, if the ages are 10, 20, and 30, and the rate of interest 4 *per cent.* we find, in the Northampton tables, the survivors at 30 4385, $\frac{8}{11}$ of which are 3199; and at 46, the survivors are 3170; whence $a=57{\cdot}7$, and $b$ and $c$ found also from periods of 16 years after the respective ages, are 68·5 and 91·7. Calculating with these numbers, we find the value of the annuity 10·954—·5 =10·454. Dr Price's short table gives it 10·438; and Simpson's approximation from the tables of two joint lives 10·563, which is less accurate in this instance, even supposing such tables to have been previously calculated.

It would, indeed, be easy to form, by this mode of computation, a table of the corrections required at different ages for Simpson's approximation, since these corrections must be very nearly the same, whether Demoivre's hypothesis, or the actual decrements of lives be employed, both for the two joint lives, and for the correct determination of the three. But the value thus found would still be less accurate, with respect to any other place, or perhaps even any other time, than the immediate result of the mode of calculation here explained.

It may, perhaps, save some trouble to subjoin a table of the values of $p$ and their logarithms.

| | | |
|---|---|---|
| 3 *per cent.* | $p=$ 33·831 | log. $p=$ 1·5293132 |
| 4 | 25·497 | 1·4064846 |
| 5 | 20·497 | 1·3116680 |
| 6 | 17·162 | 1·2345630 |

(RT.)

END OF VOLUME FIRST.

# TABLE

OF THE

## ARTICLES AND TREATISES

## CONTAINED IN THIS VOLUME.



* This reference was omitted in its proper place in the Volume.

* This, and the following reference, were omitted in their proper place in the Volume.
† This reference was omitted in the Volume.

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